Subsurface Site Characterization Methodology; Example from Pennsylvanian Carbonate Reef, West Texas

DOE Southwest Partnership Pilot at SACROC and Claytonville oil field sites

02/16/2006

Acknowledgements

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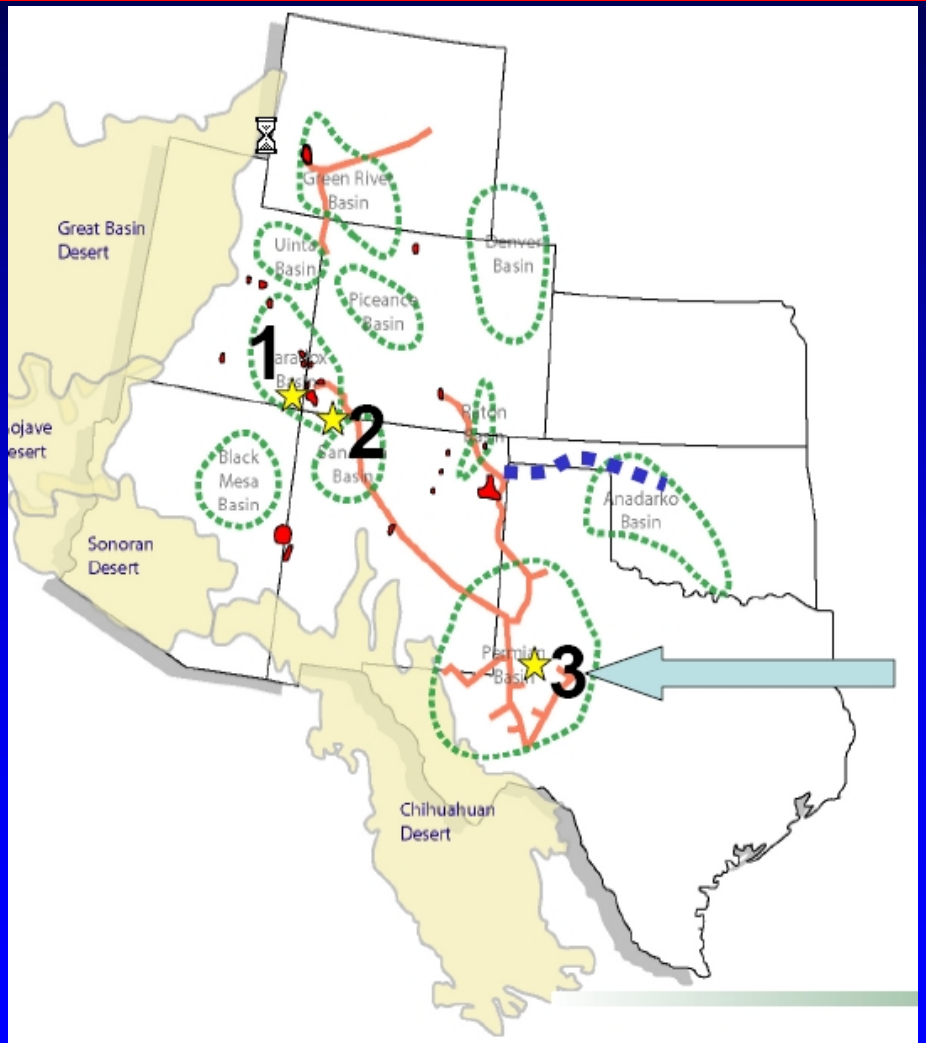
New Mexico Institute of Mining and Technology

Special Acknowledgement to Industry sponsor Kinder Morgan

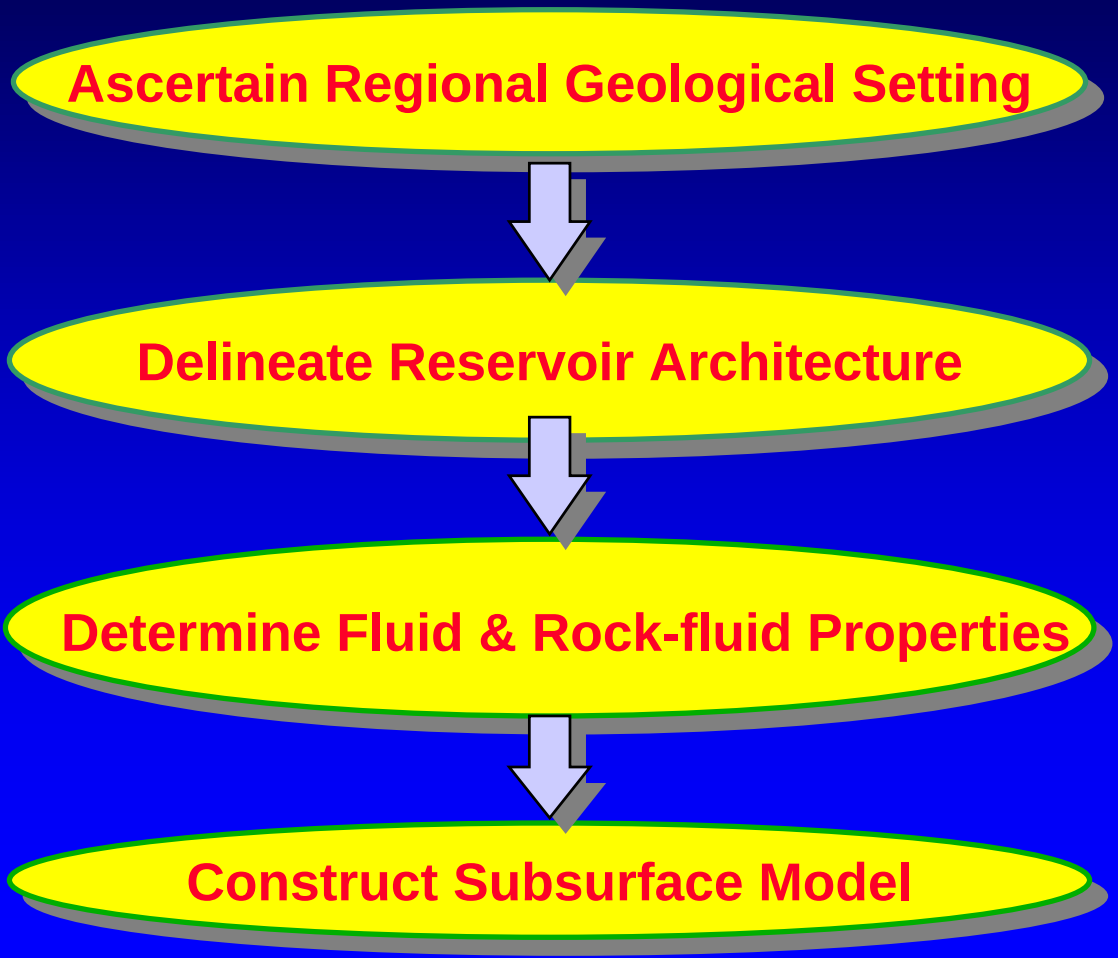
DOE Southwest Partnership Phase 2 Pilot Sites

Bureau of Economic Geology



Carbonate Reef CO_2 Sequestration

Subsurface Site Characterization Work Flow



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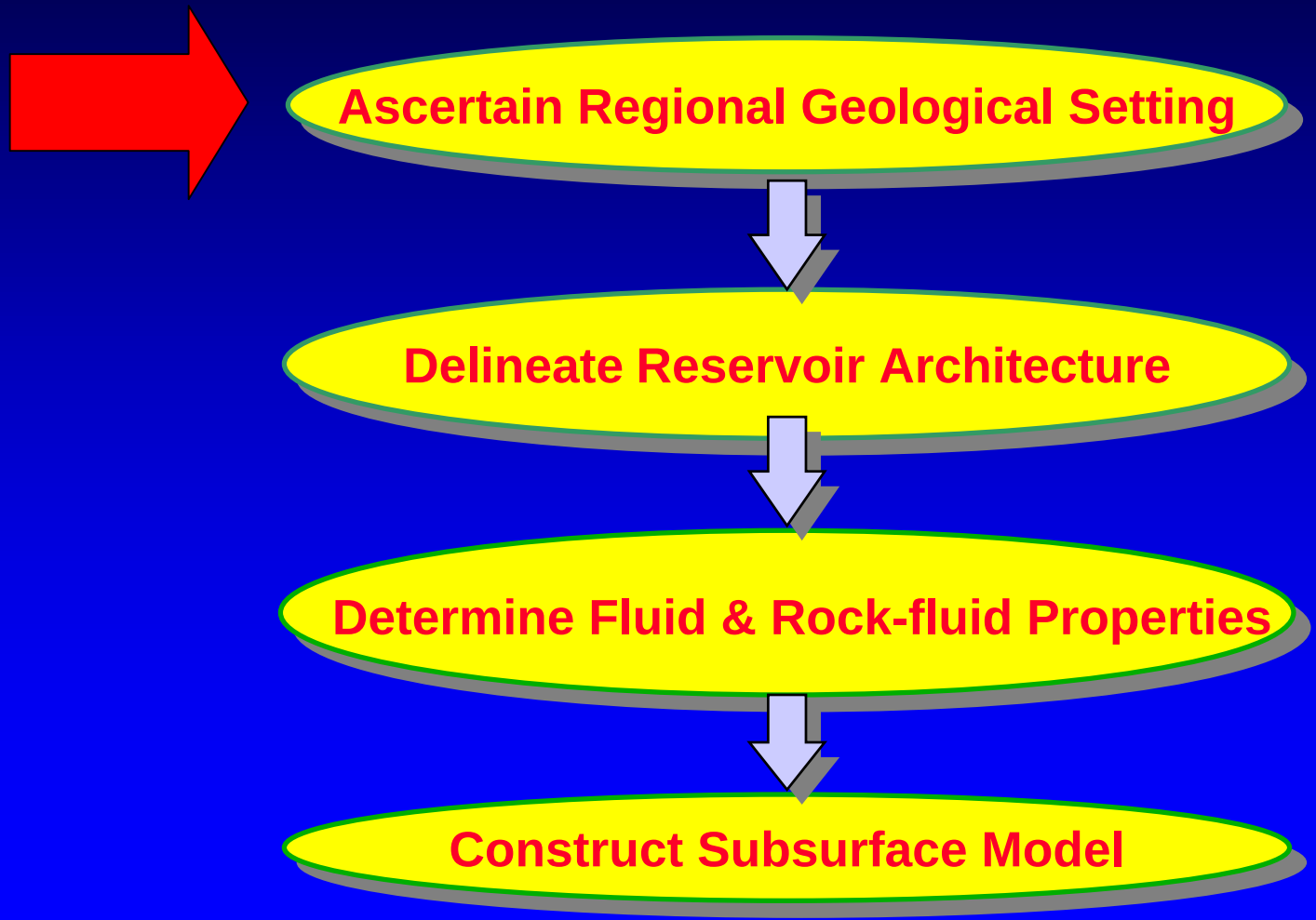


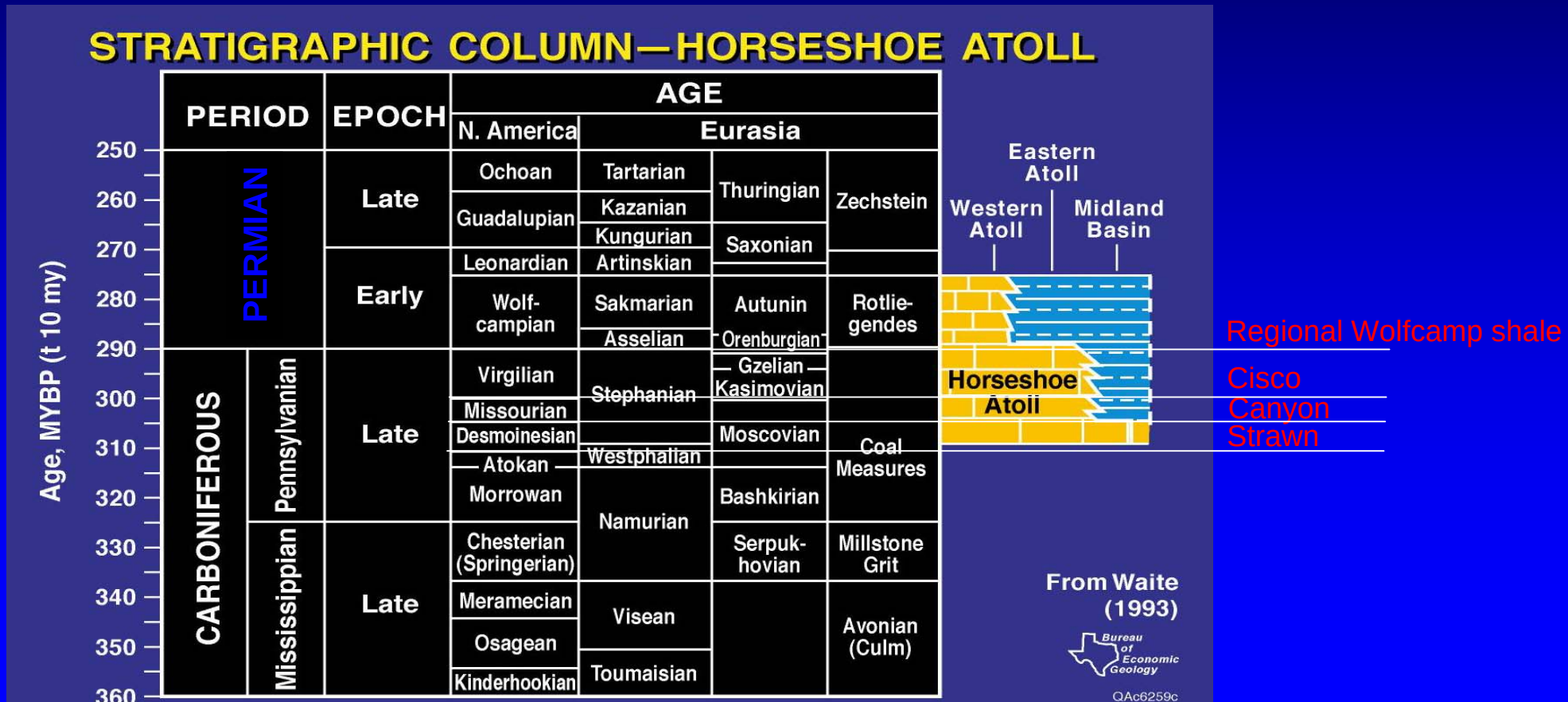
Ascertain Regional Geological Setting

1. Determine regional geological stratigraphy
2. Recognize and correlate large scale chronostratigraphic flooding surfaces
   - ➢ markers are represented by high gamma and/or low SP response
3. Interpret basin shape and filling style
   - – progradational, aggradational, transgressive
4. Delineate regional seals
5. Identify major fault systems

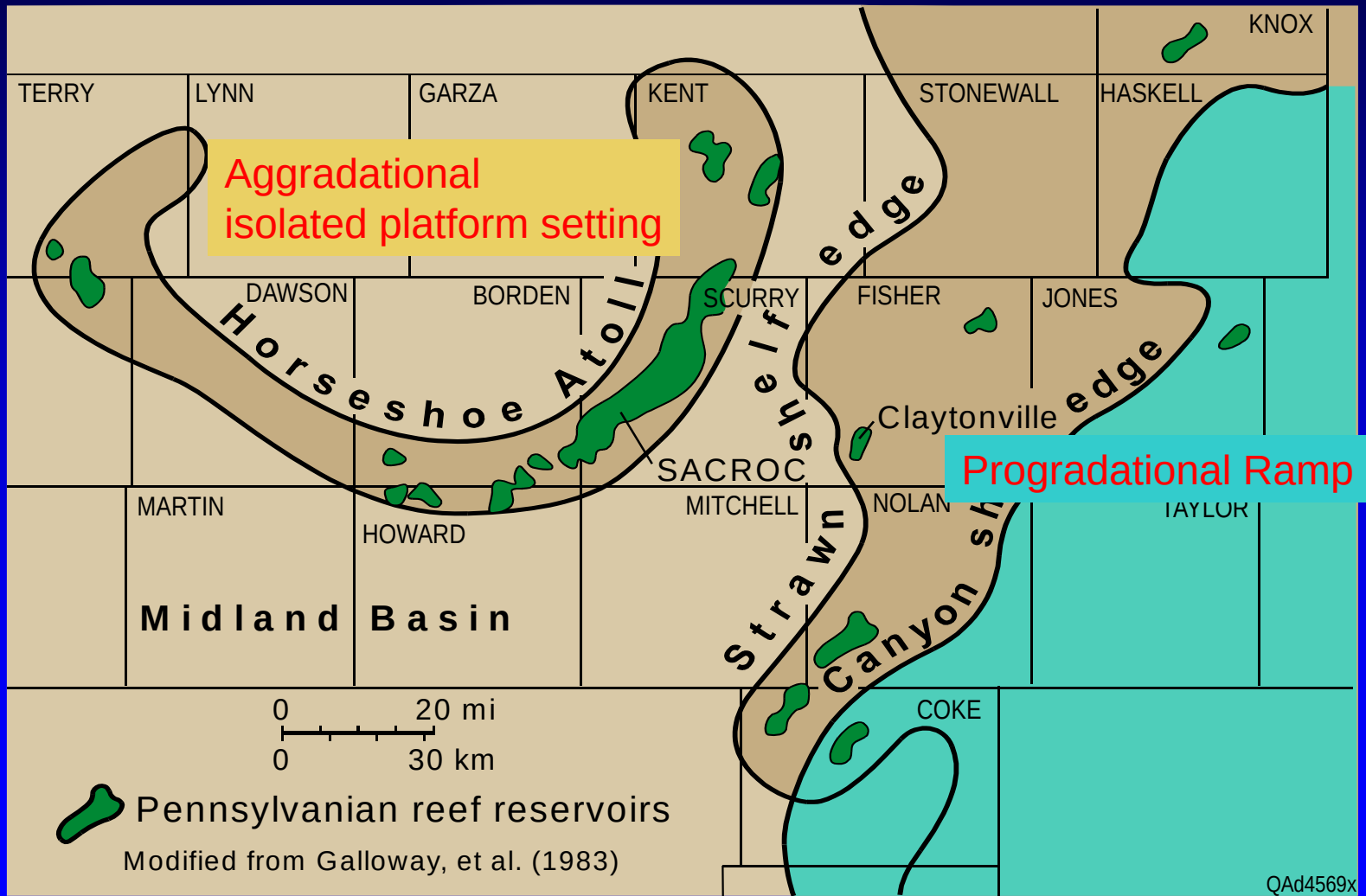
West Texas Pennsylvanian Carbonate Reef Stratigraphic Setting

Bureau of Economic Geology

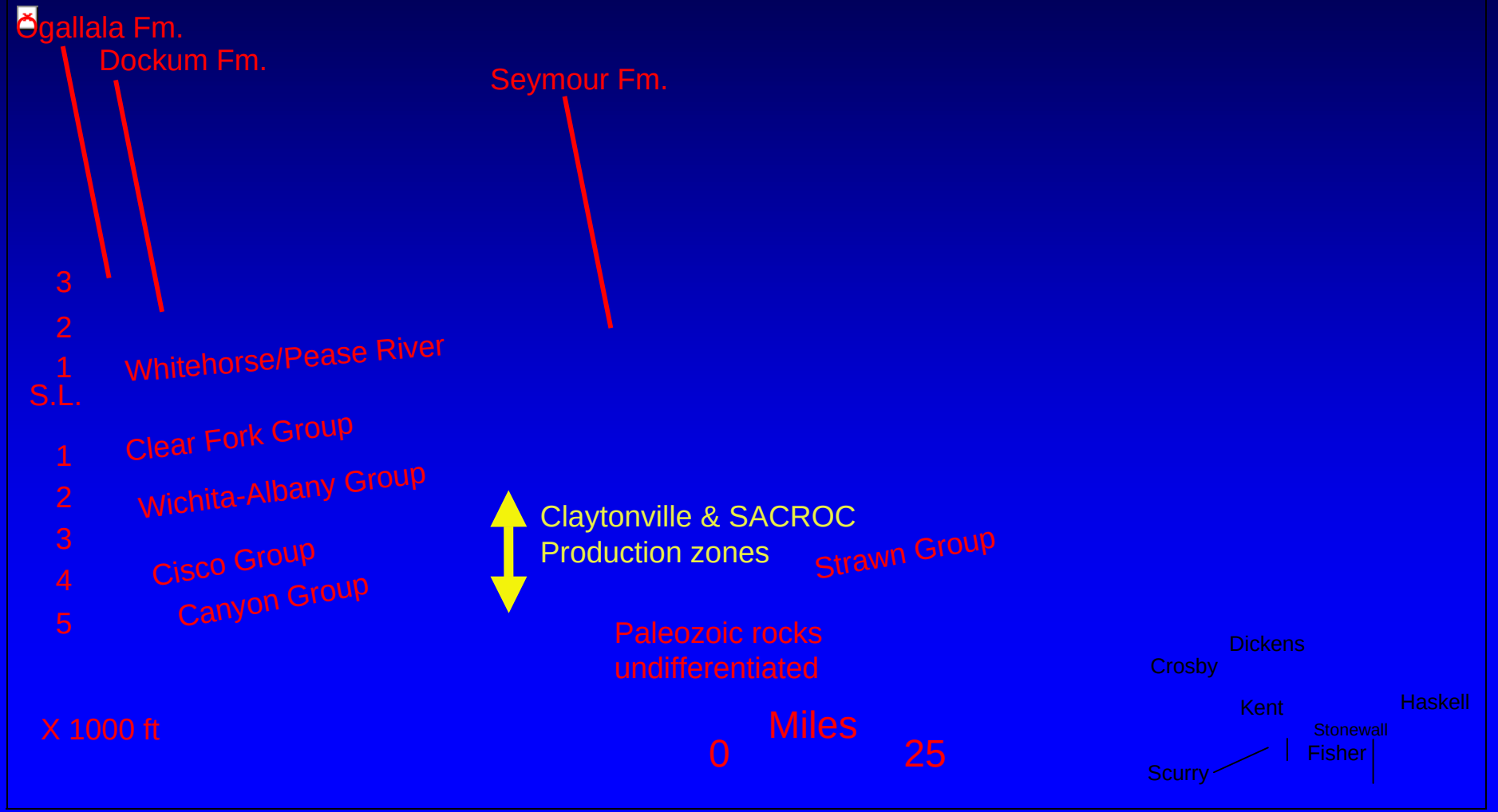
Reservoirs produce from Canyon- Middle Cisco age (290-307 Ma) platform and slope carbonates



SACROC & Claytonville Location and Regional Geology



Eastern Shelf Stratigraphy



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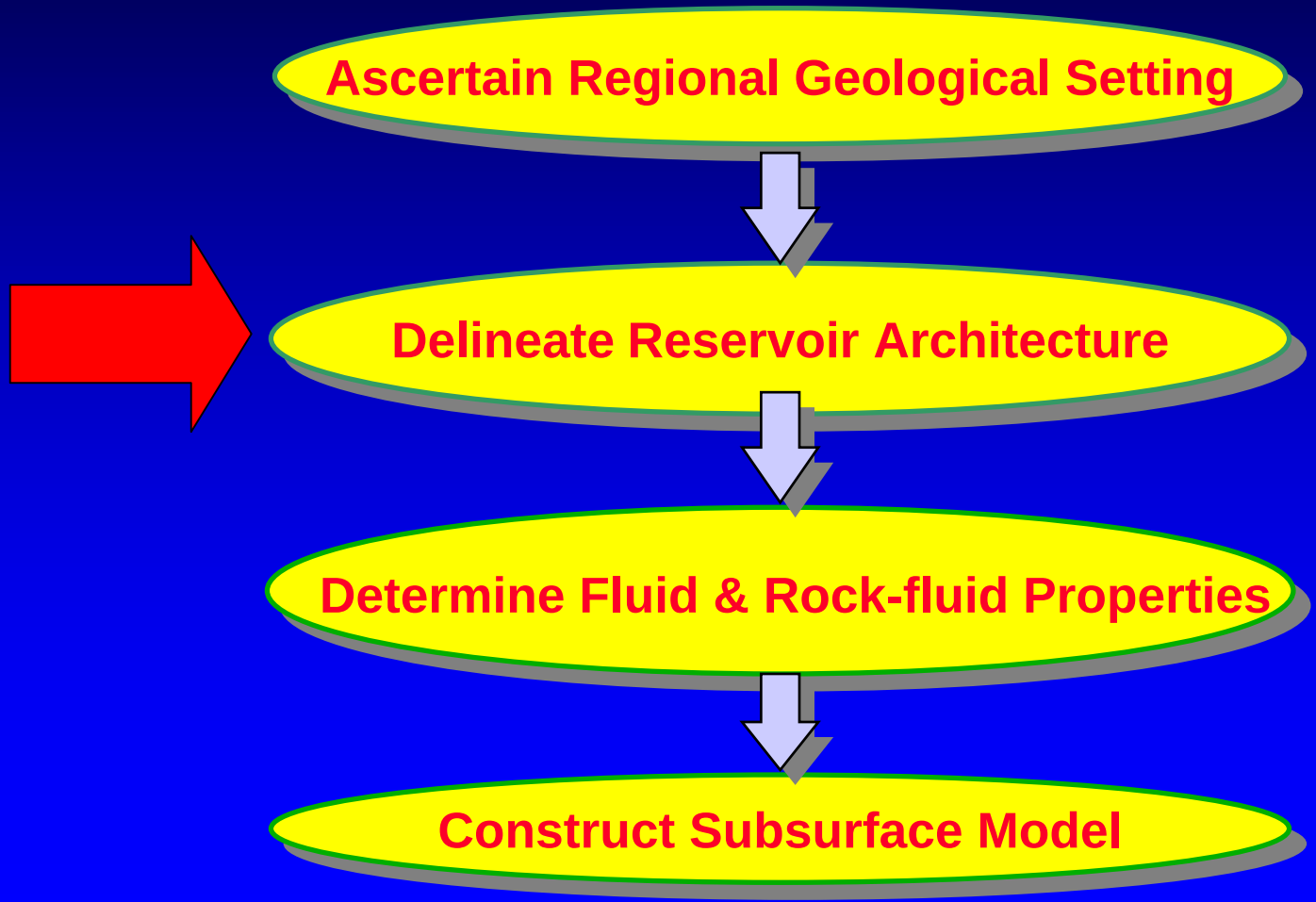
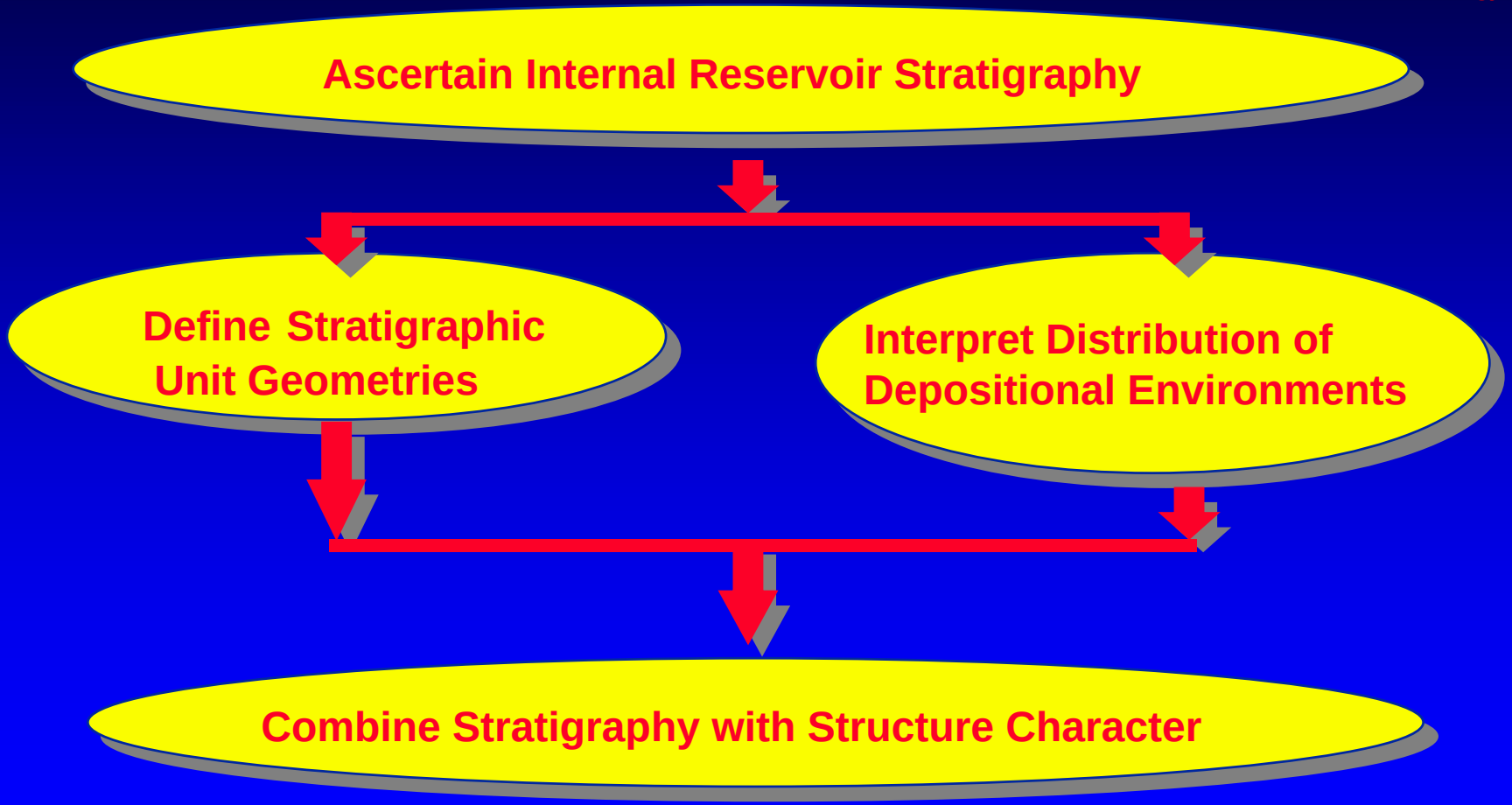


Delineating Reservoir Architecture

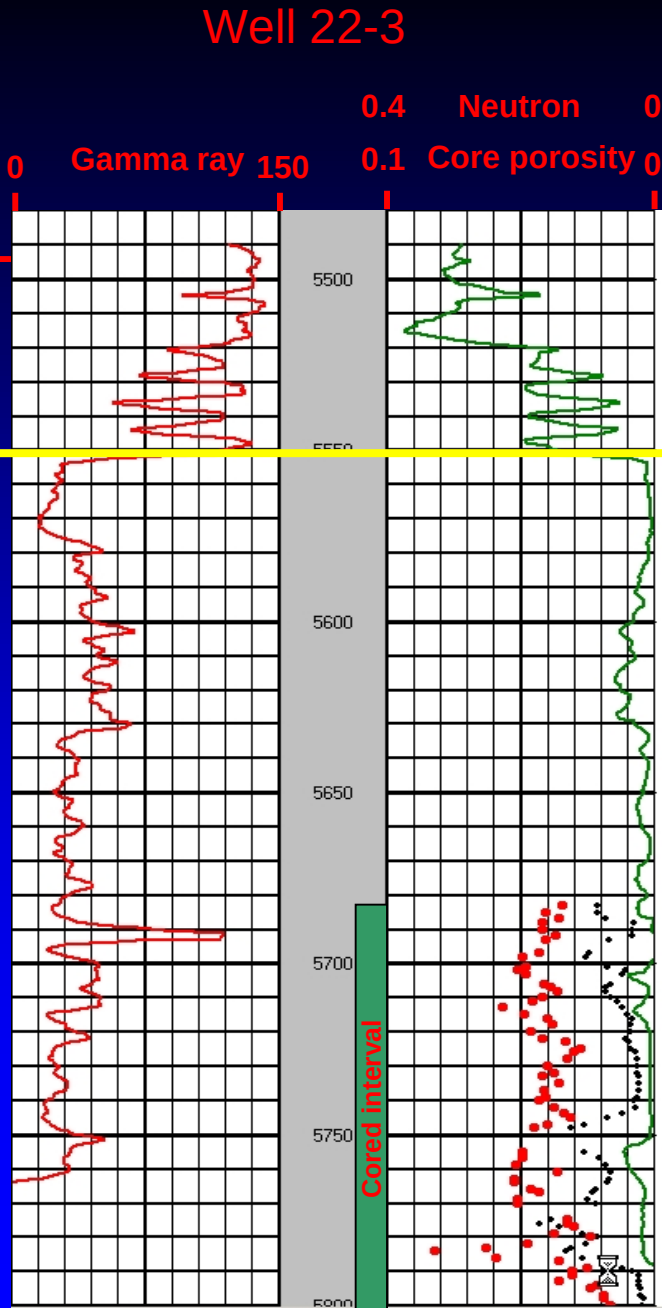


Claytonville Canyon Lime Type Log

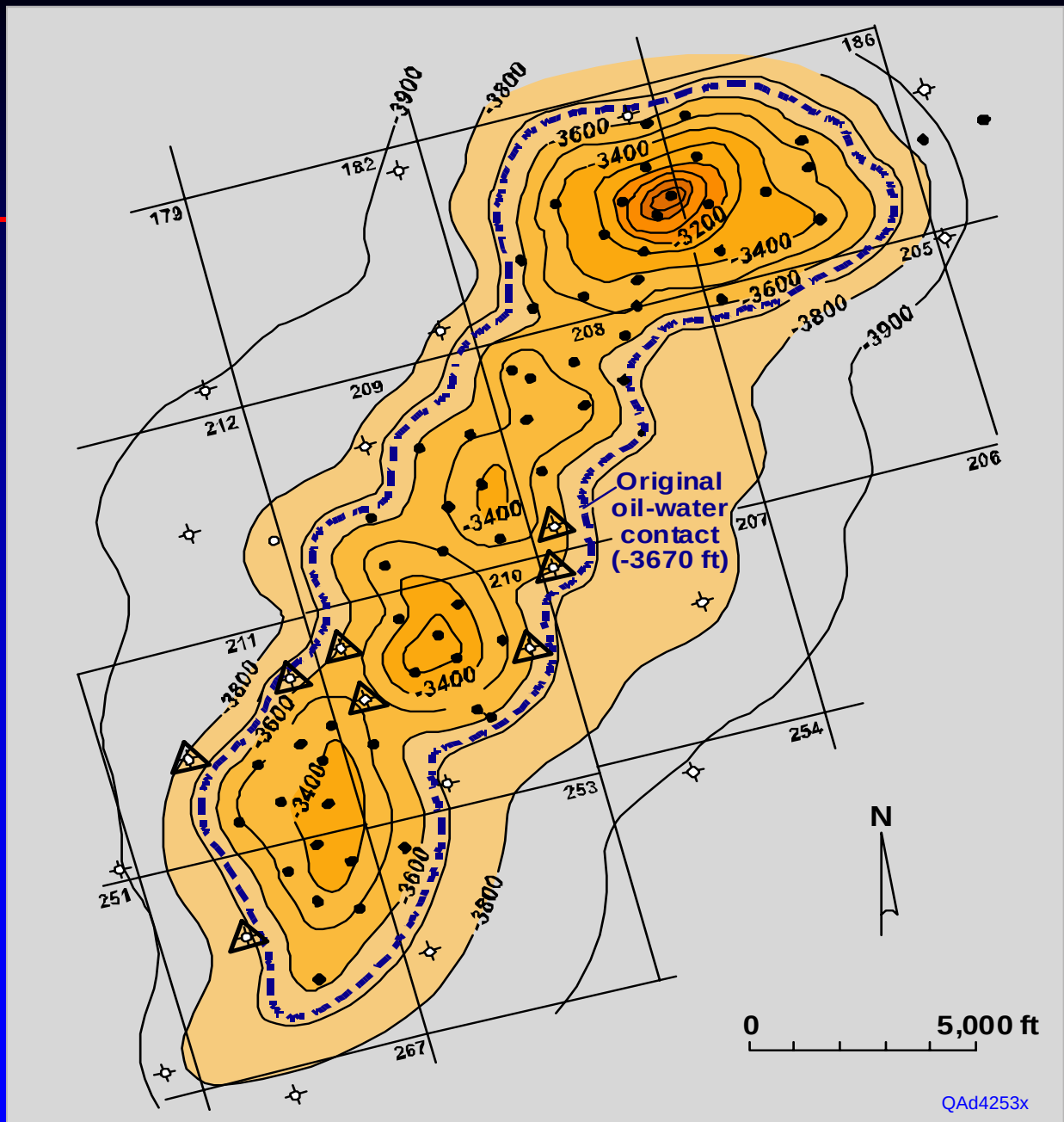
Wolfcamp shale

Top of reservoir

Canyon carbonate reservoir



Claytonville Top of Structure



Lower reservoir composed of shoaling upward cycles

Cycle Top

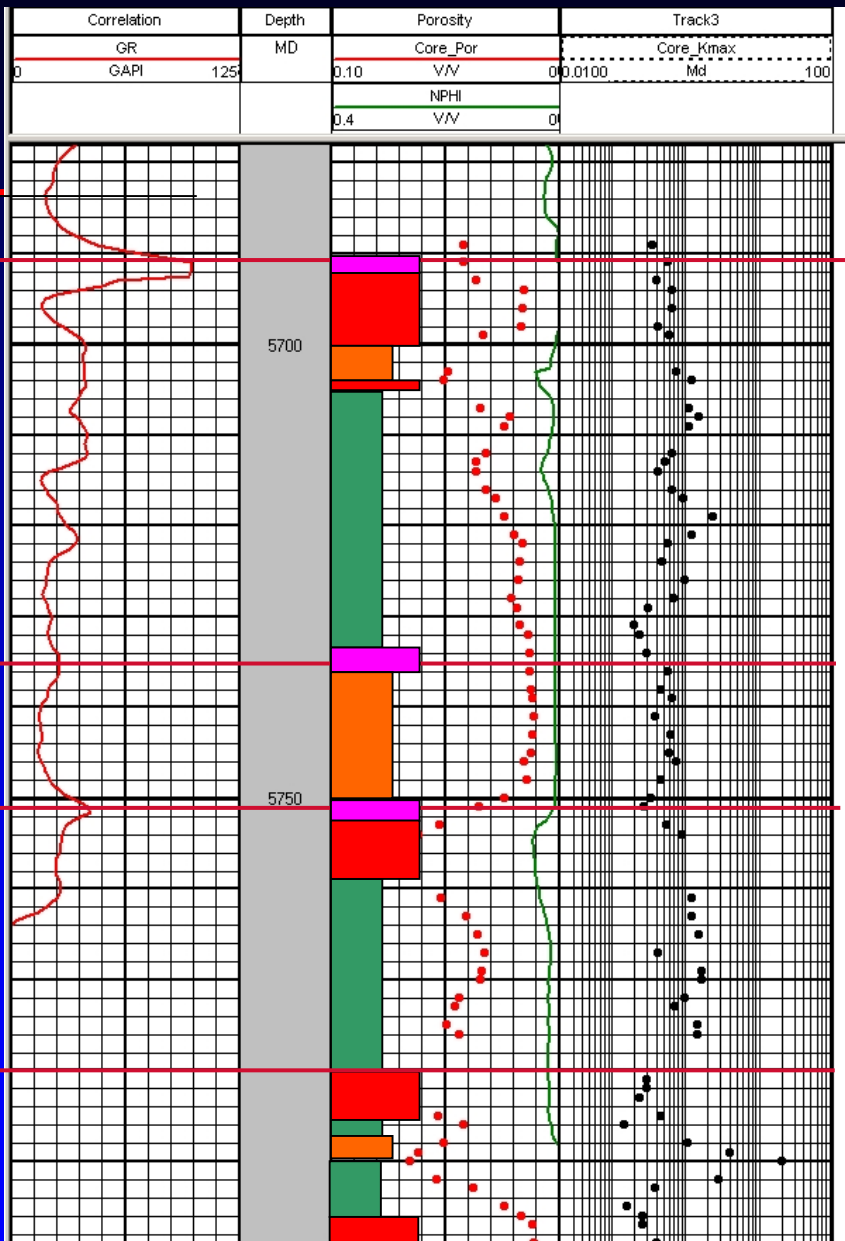
Breccia

Grainstone

Skeletal pkst

Crinoid wkst

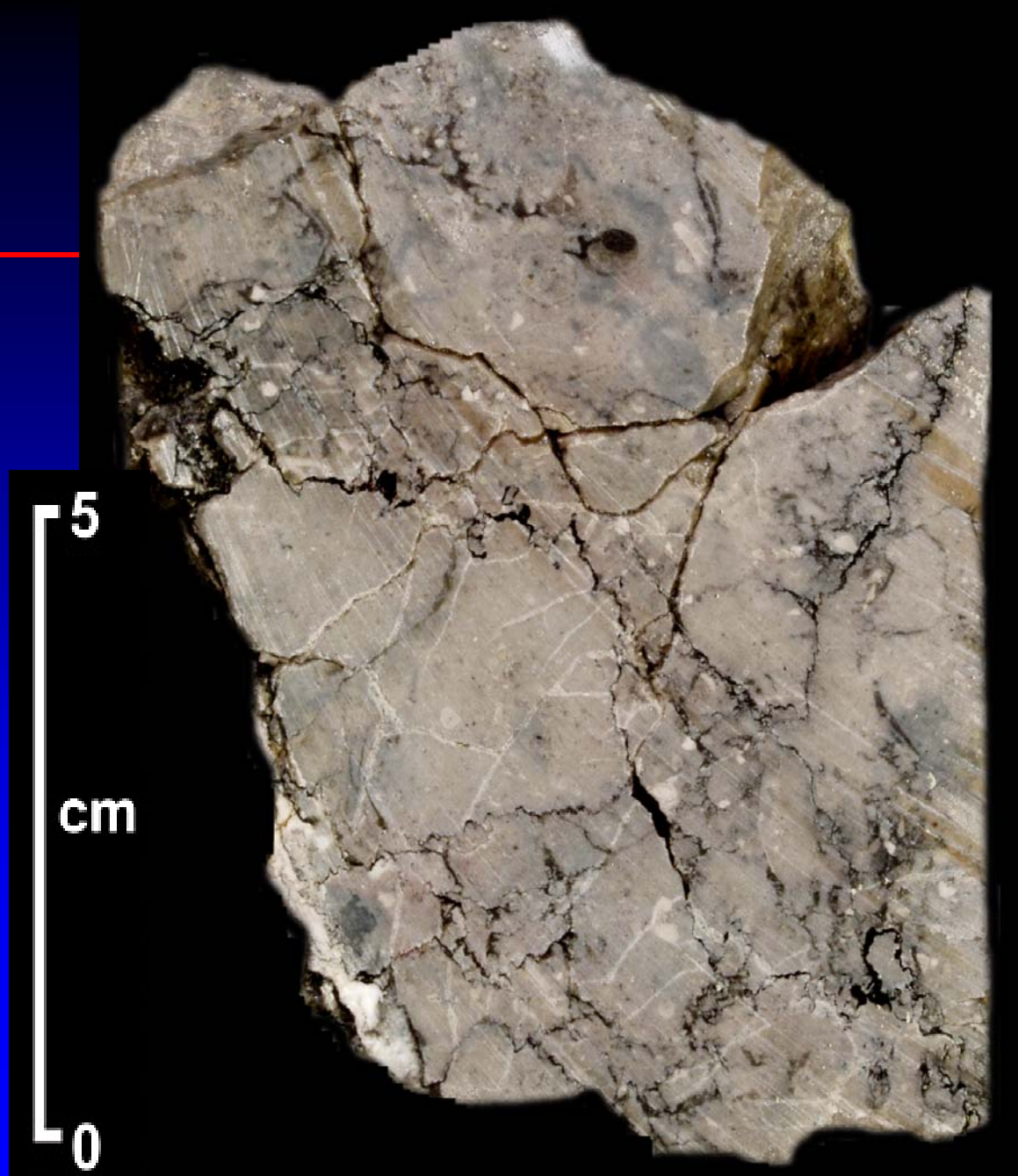
Mudstone



Fractured Mudstone

Webb # 3

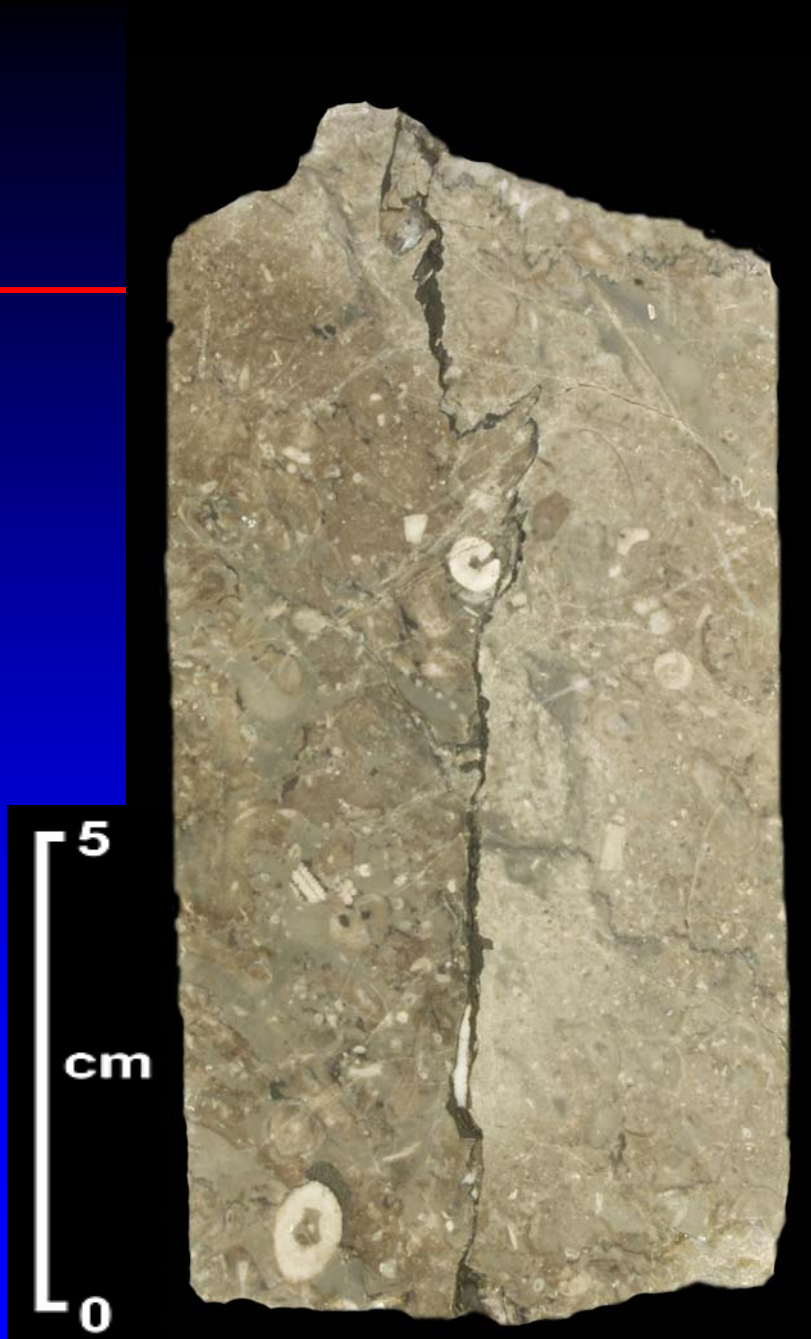
5,687b ft



Crinoid Wackystone

Webb # 3

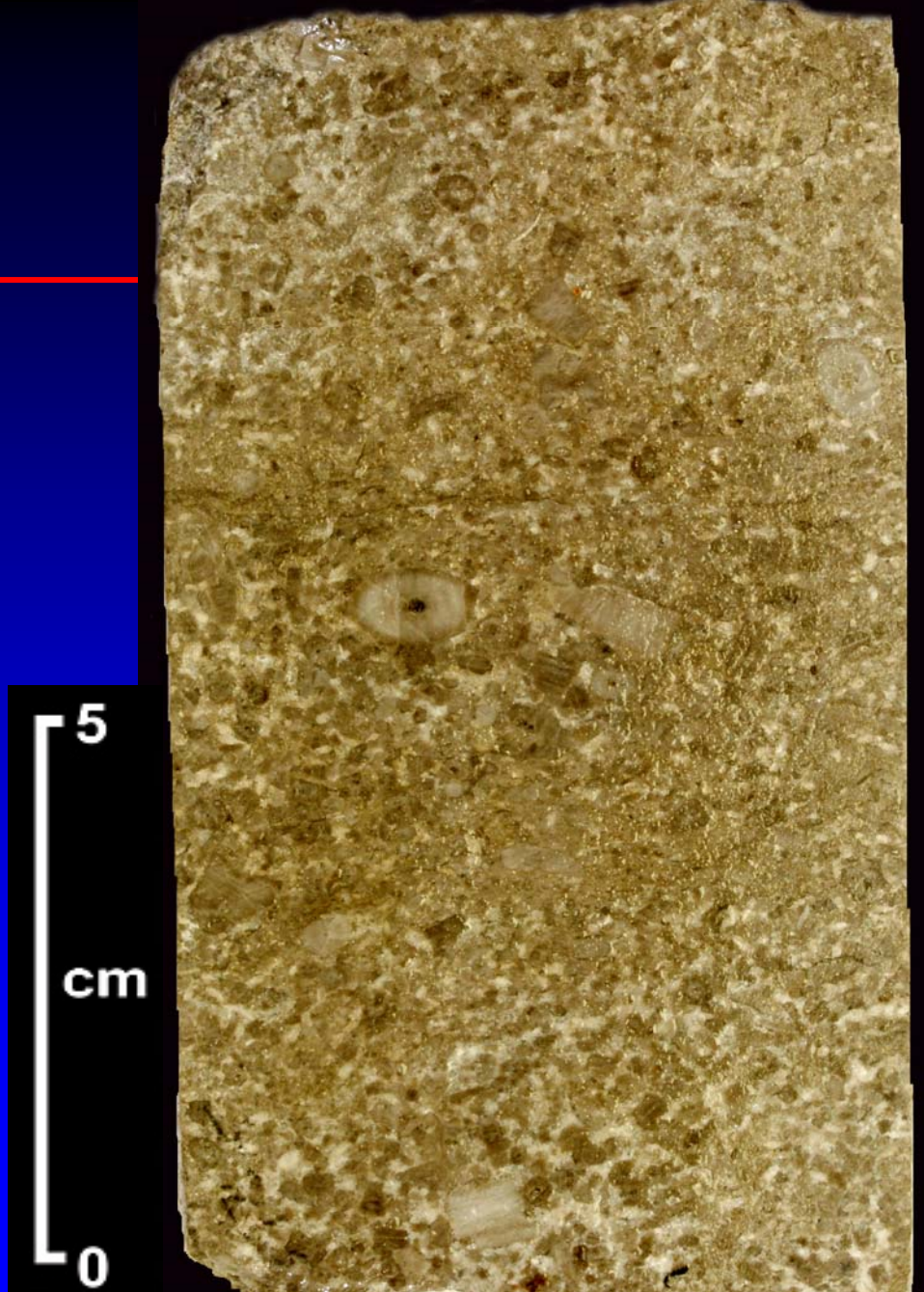
5,684 ft



Grainstone

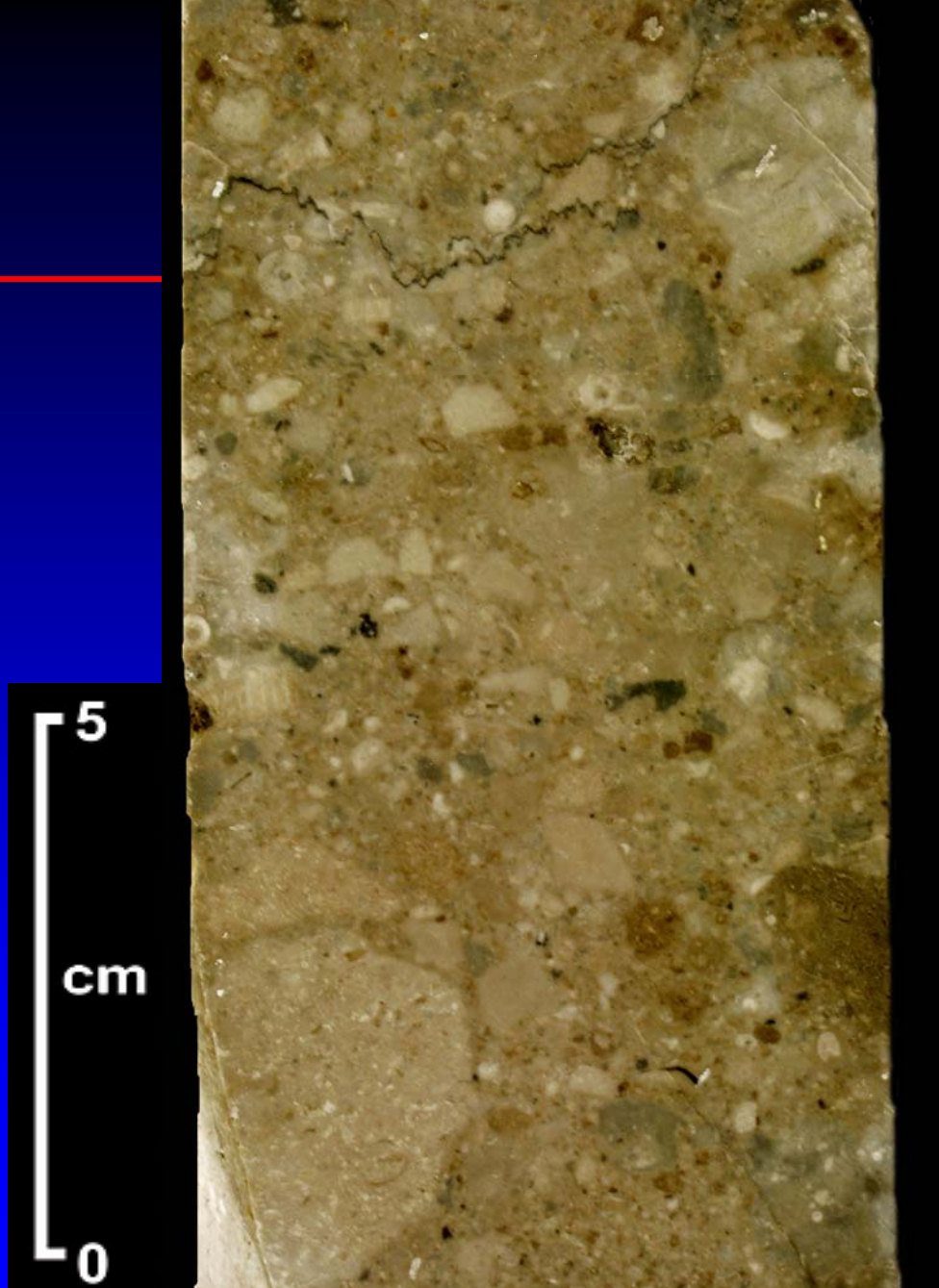
Webb # 3

5,778 ft



Breccia

Webb # 3
5,726b ft

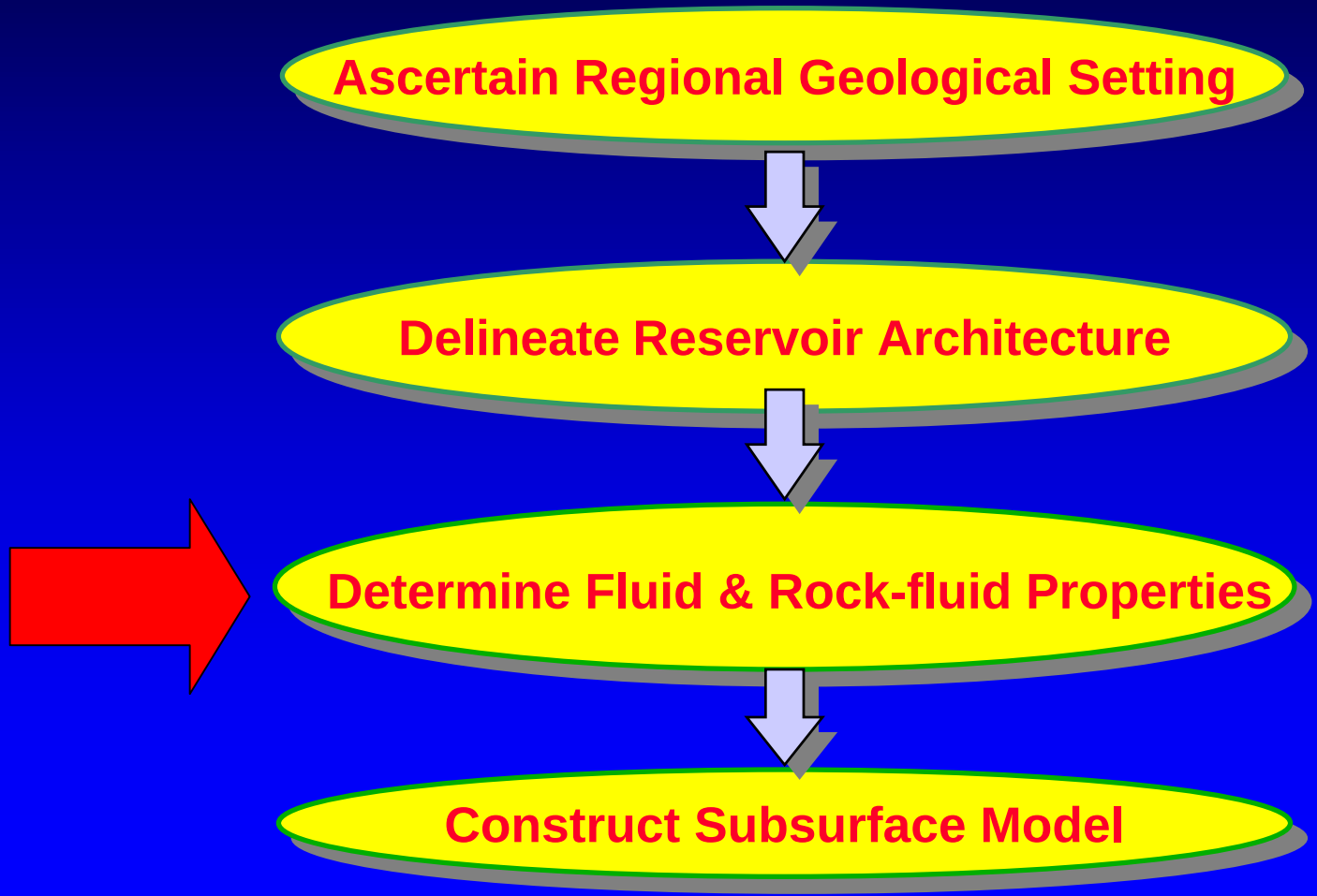


Breccia
Webb # 2
5,448 ft

Large Vugs

Webb #2
5,448a

Subsurface Site Characterization Work Flow

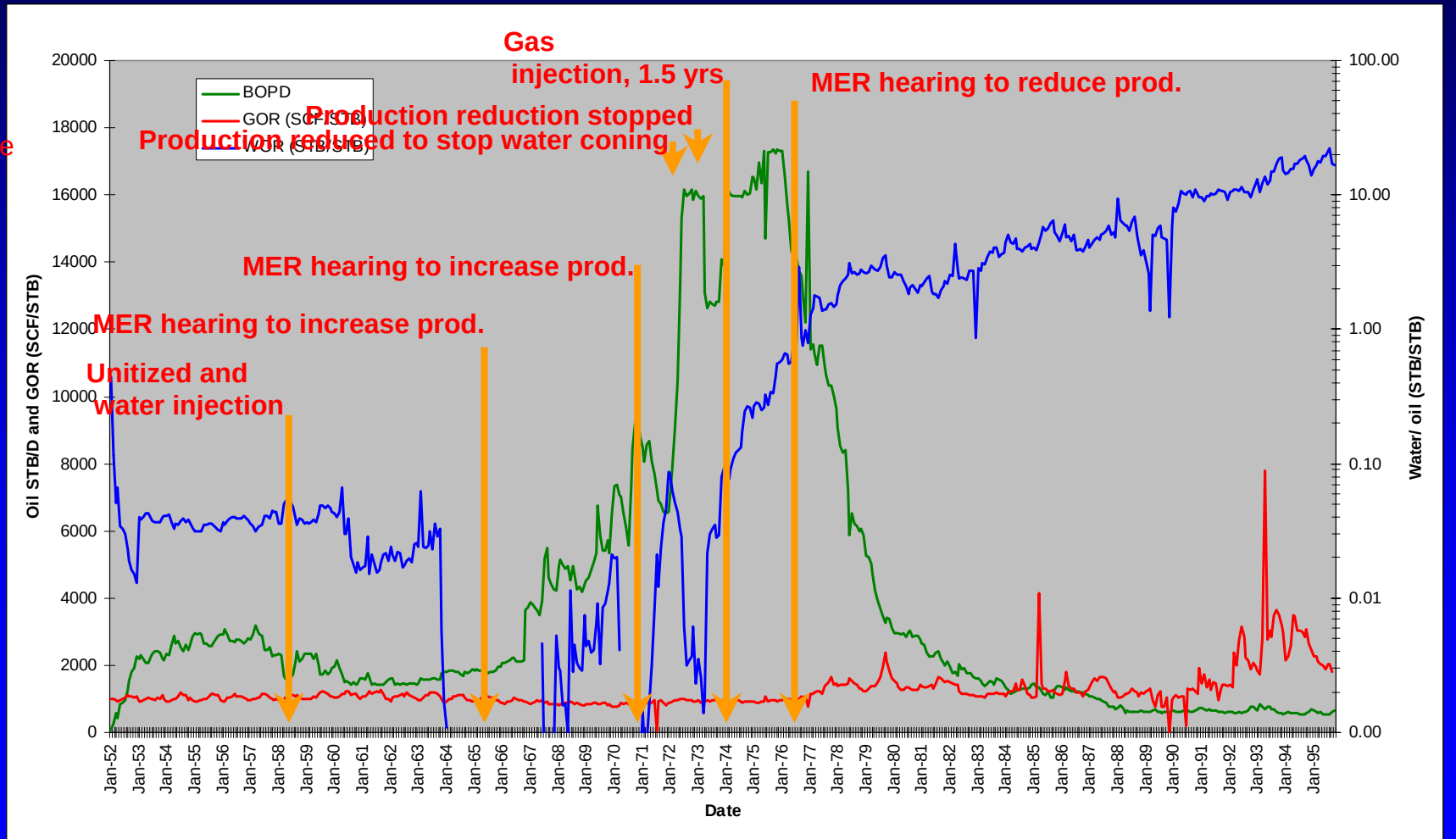


Tasks For Establishing Fluid Flow Trends in a Reservoir

1. **Ascertain the initial fluid Properties**
    1. **Reservoirs fluid properties**
    2. **Overlying water properties**
2. **Rock-fluid petrophysical properties**
3. **Generate a production time series analysis**
4. **Assess well test data**
5. **Determine flow directions of injected fluids**

Claytonville Production and Development History

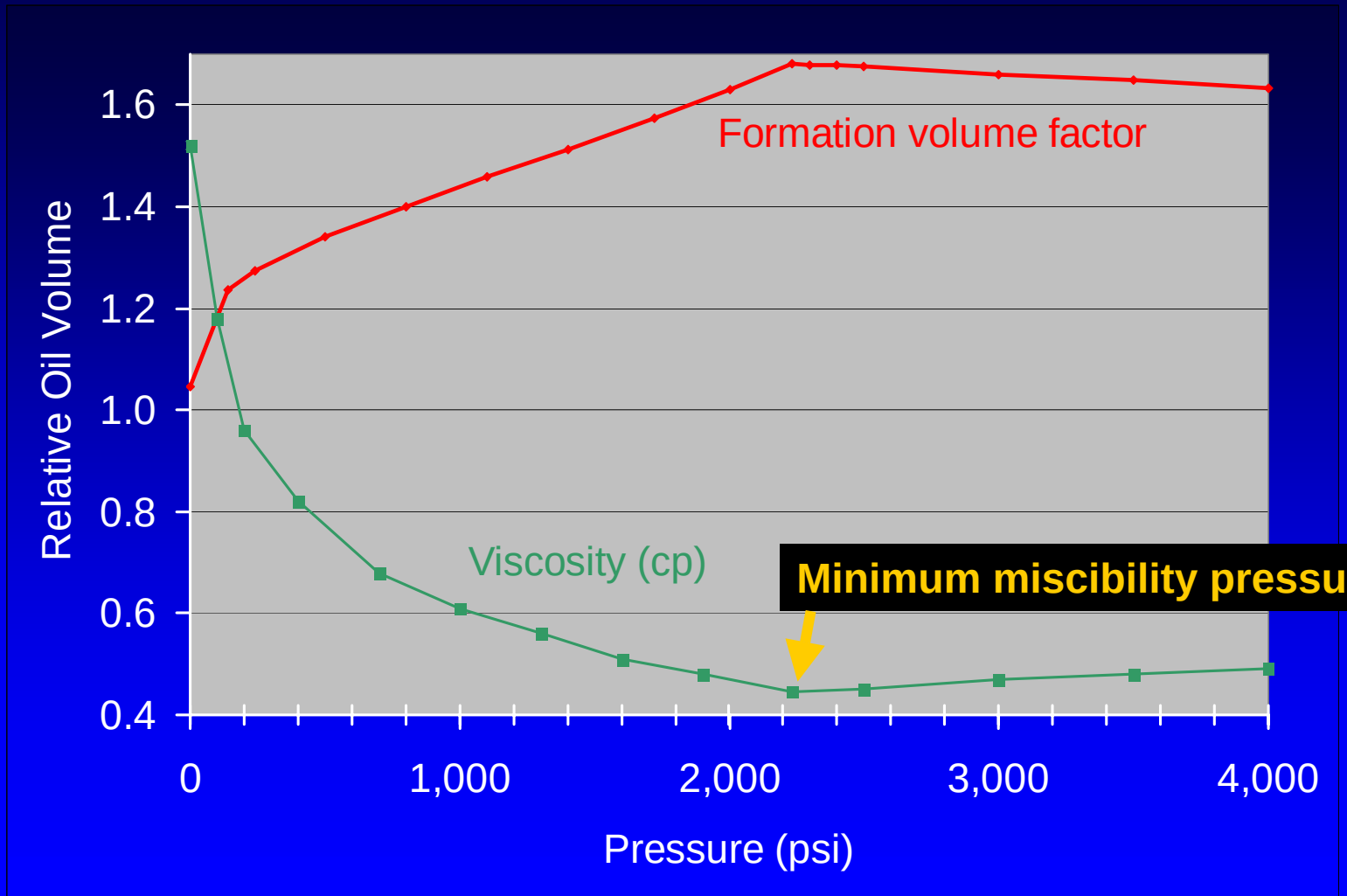
Set MER rate



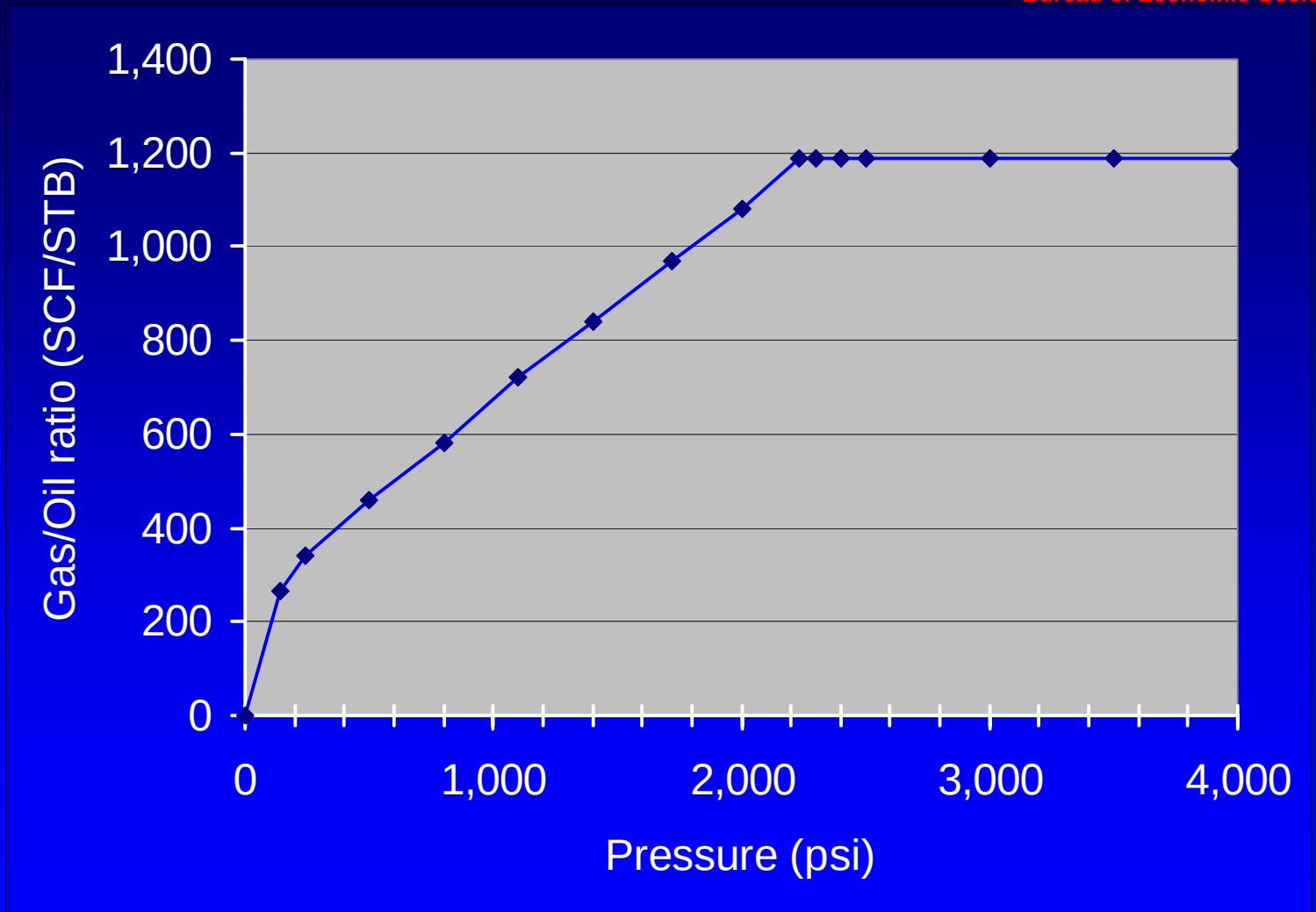
Fluid Characteristics

- Initial GOR: 1200 scf/STB
- Oil API gravity: 42
- Original oil formation volume factor: 1.510
- Bubble point pressure (psi): 1850
- Oil viscosity @ P_b (cp): 0.35
- Sulfur content of oil: 0.32
- Gas gravity: 1.13
- Connate water salinity (PPM): 59,000

Claytonville Oil Character



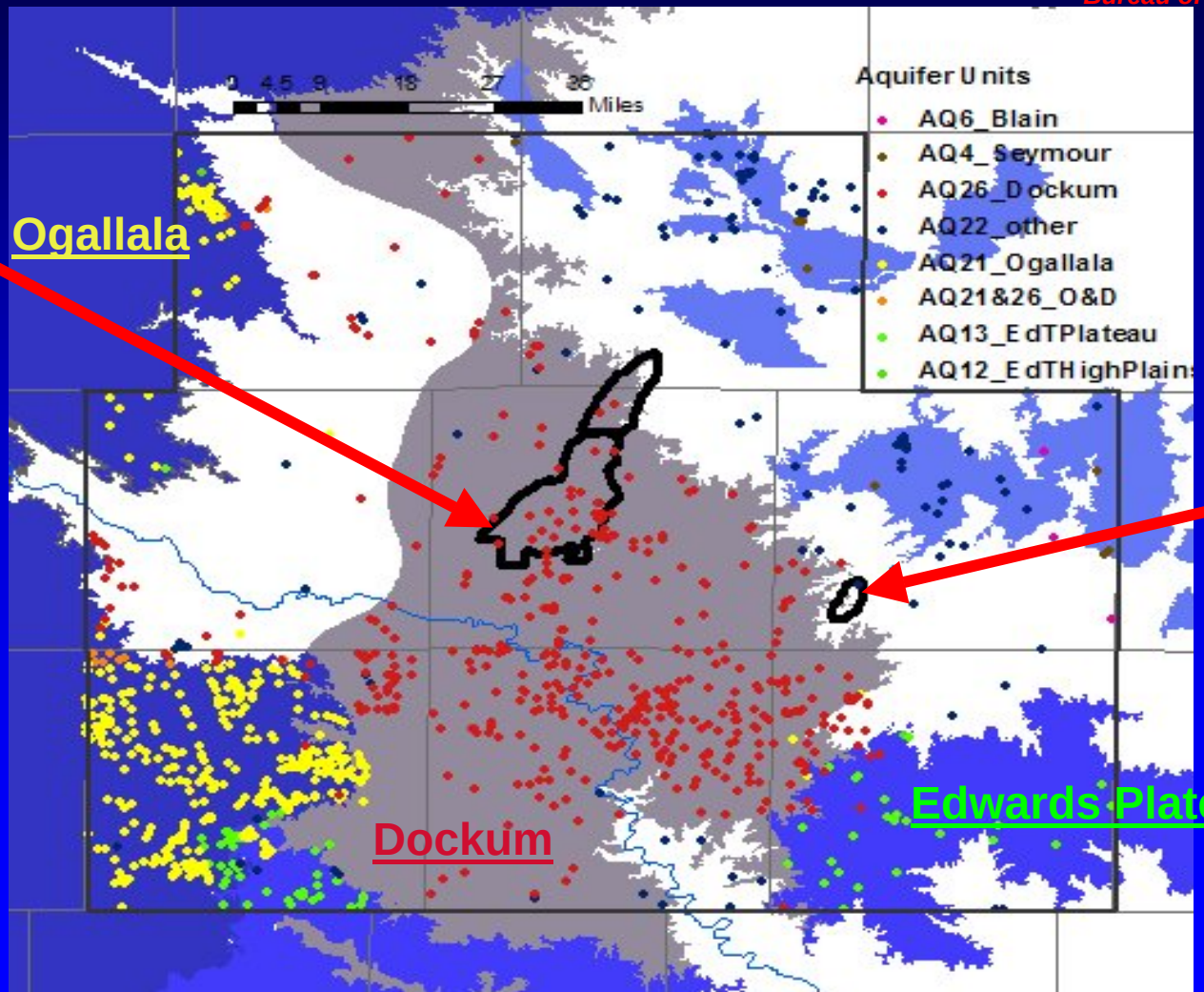
Gas - Oil Ratio
Claytonville Oil Character



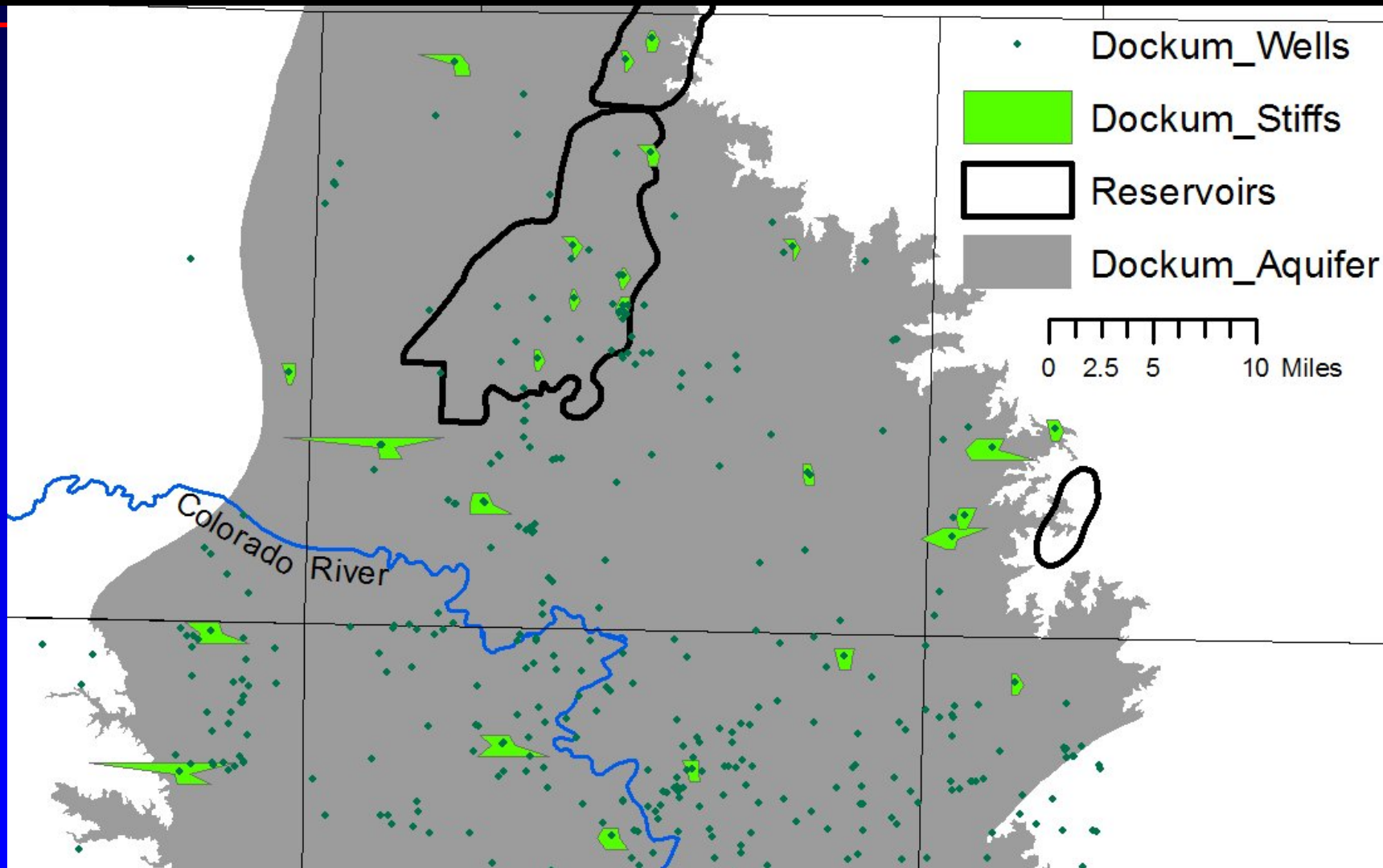
Groundwater Characterization

- Compile existing data from eight county study area
- Identify regional variability of existing analyses,
- Additional groundwater sampling (Install 4 new water wells in Claytonville)
  - major ion, total organic carbon,
  - stable isotopes of hydrogen (D/H), oxygen ($^{18}O/^{16}O$), and carbon ($^{13}C/^{12}C$);
  - Sr isotopes (reservoir brines and shallow groundwater)
  - pH, temperature, and alkalinity field measurements,
- Geochemical equilibrium and flowpath modeling to identify groundwater mixing.

Major and Minor Aquifers and Sample Wells



Mapping water chemistry with stiff diagrams



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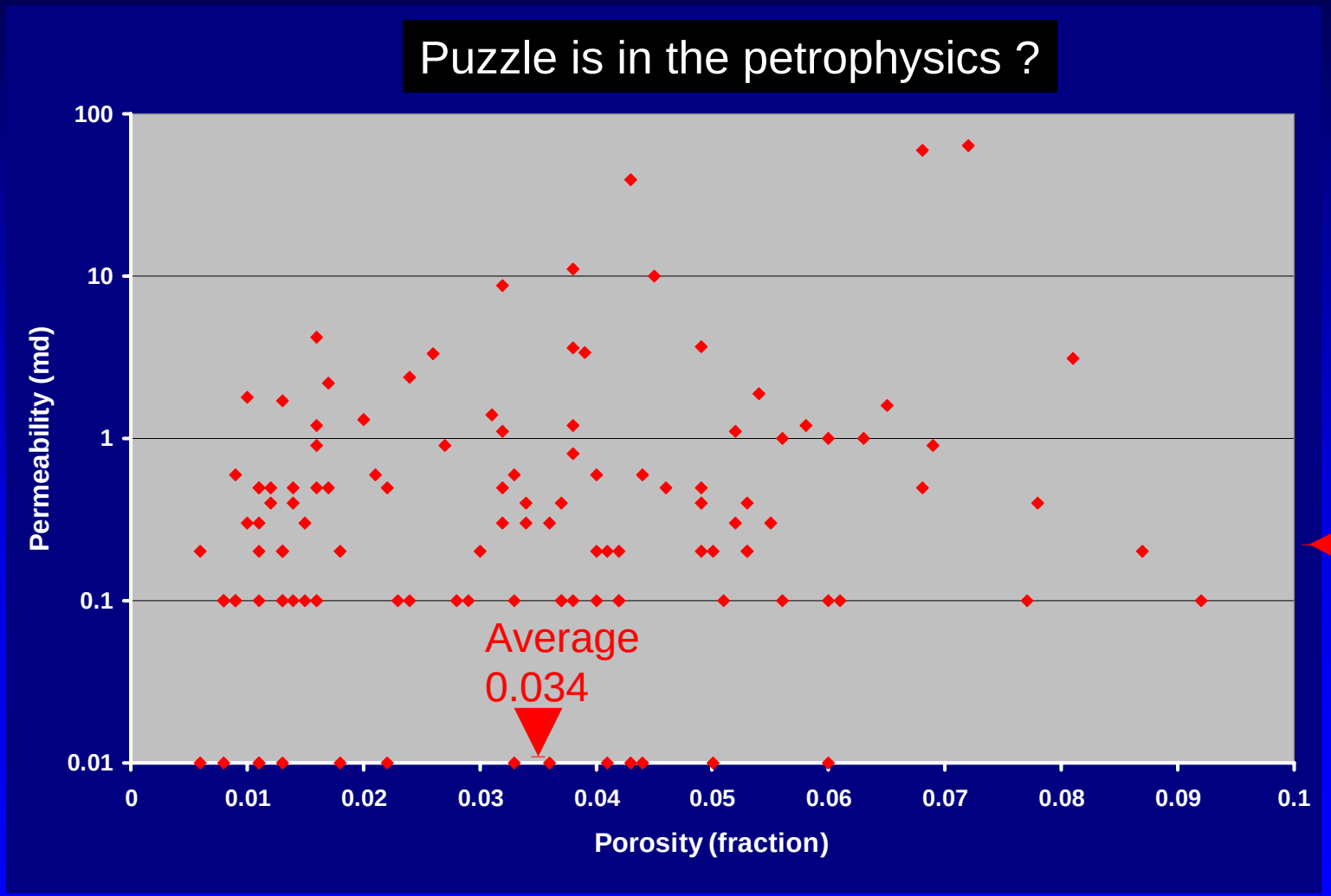
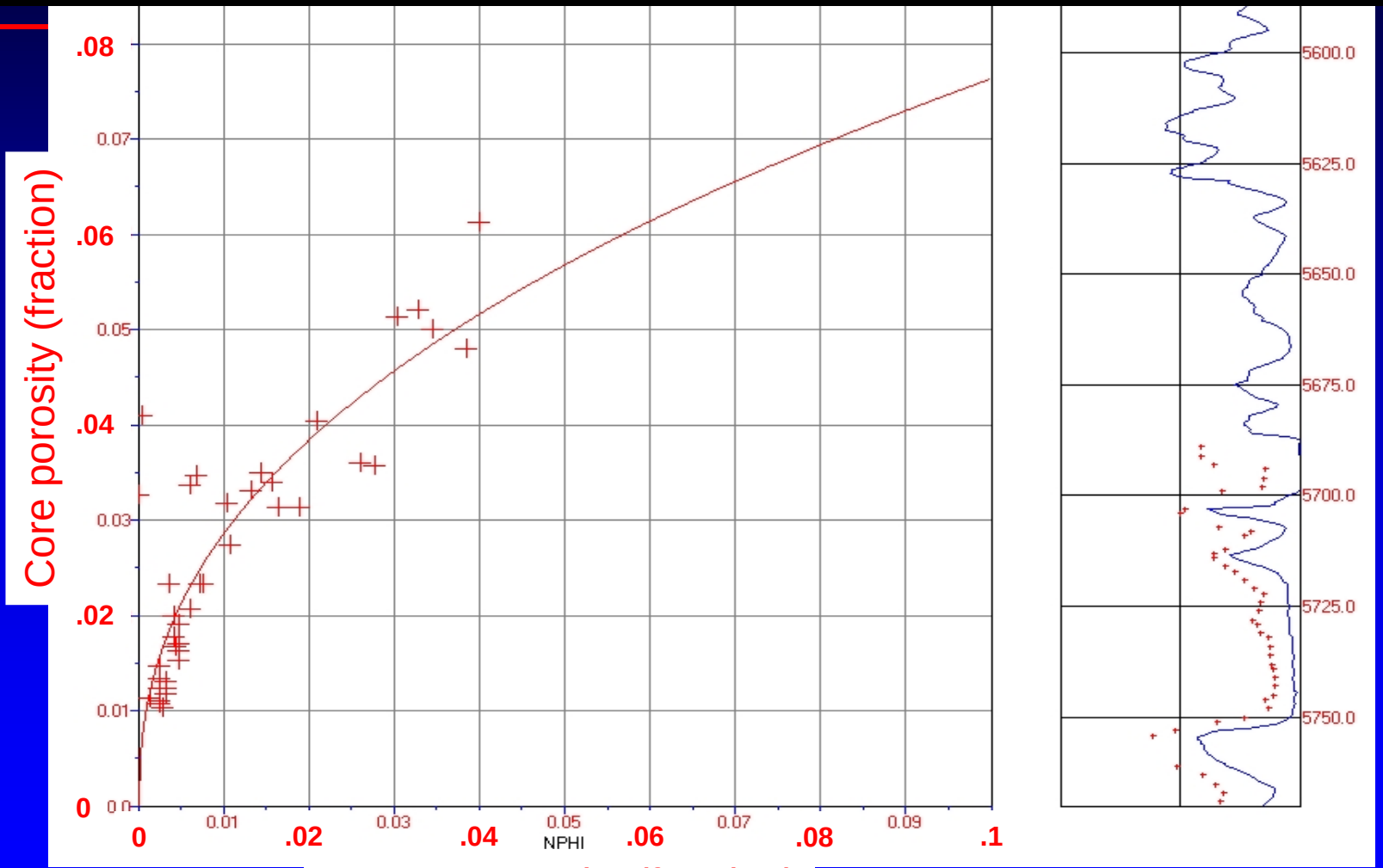
Porosity-Permeability Character Core Data Well 22-3

Puzzle is in the petrophysics ?



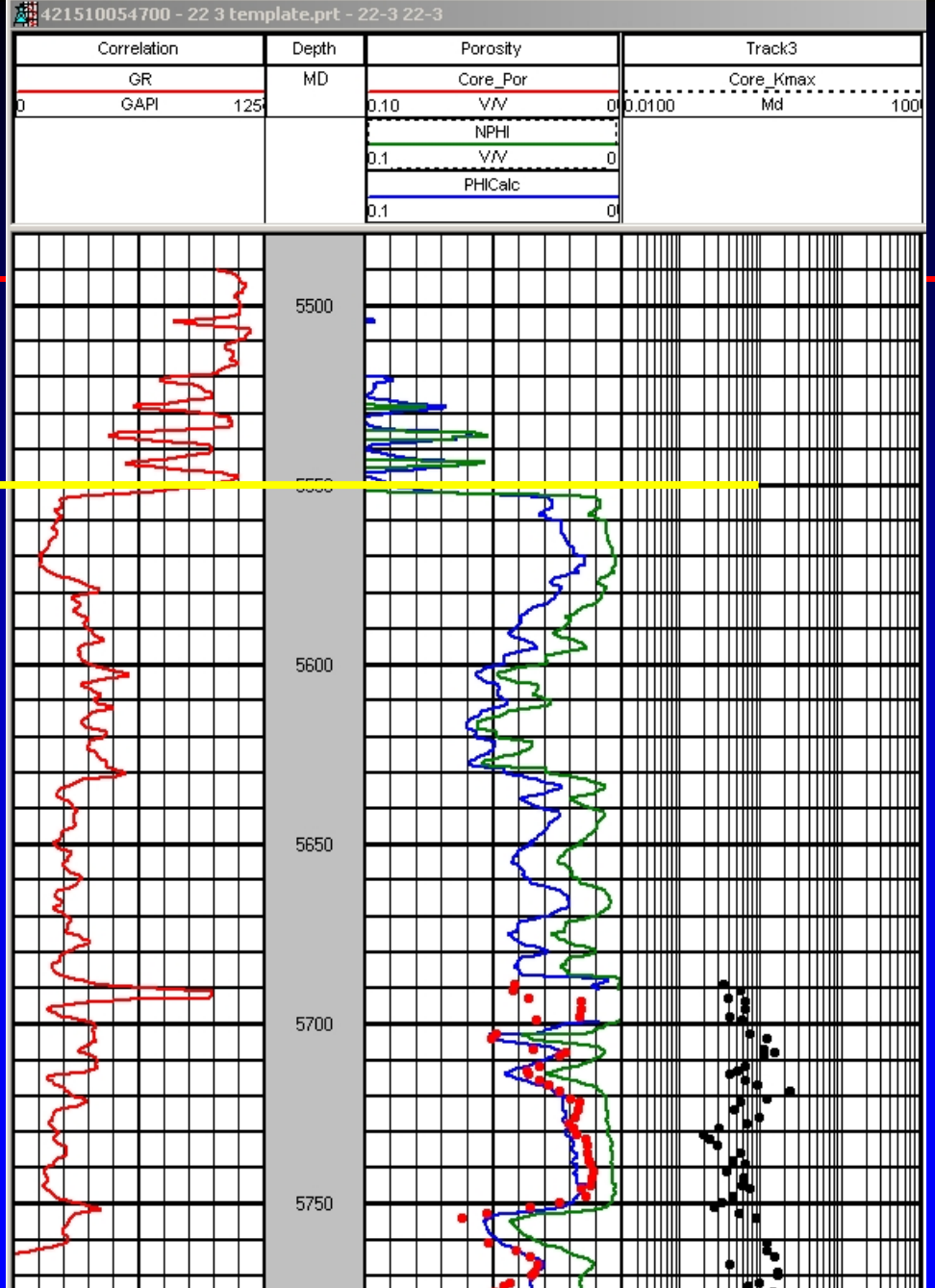
Permeability Geometric Average 0.283 md

Relationship Between Neutron Wireline and Averaged Core Porosity; Well 22-3



Transform derived porosity

Top of reservoir



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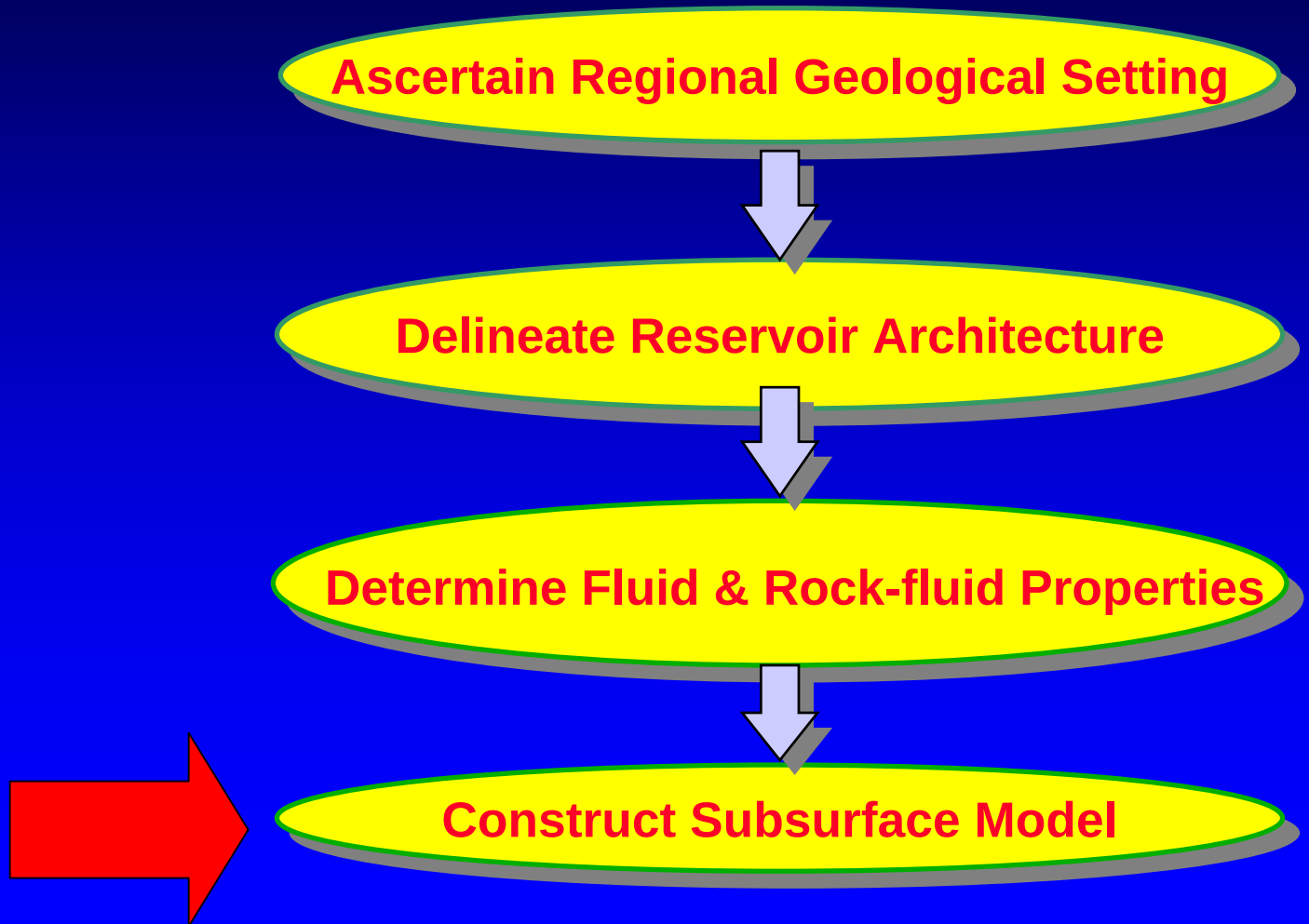
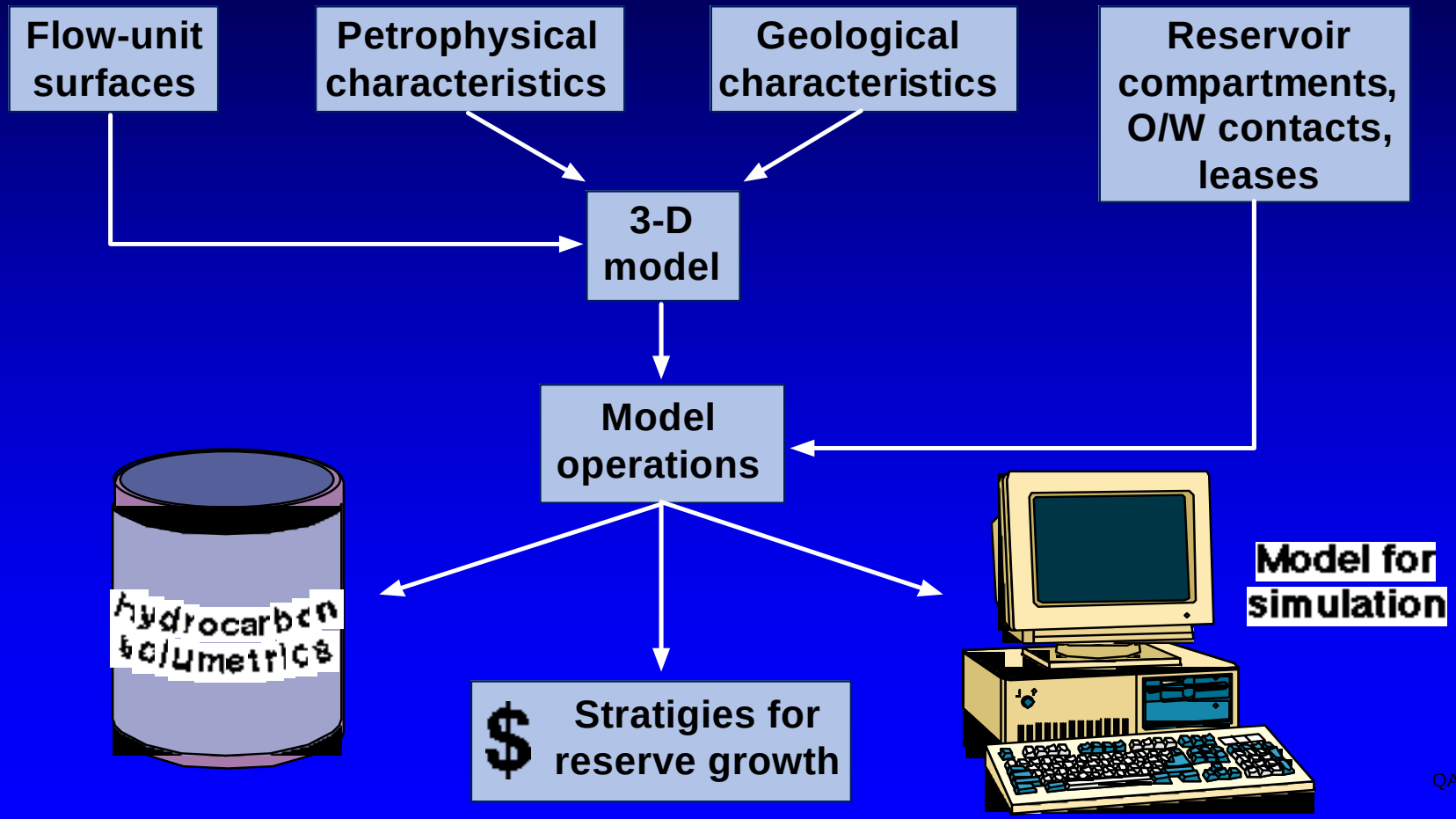


Inputs into a 3-D Geocelluar Model



QAb1612c

SACROC Conceptual model description

Model describes Cisco and Canyon formations in Pennsylvanian

Number of grids: 18 x 35 x 26 = 16380

TOUGH2 simulator has been used

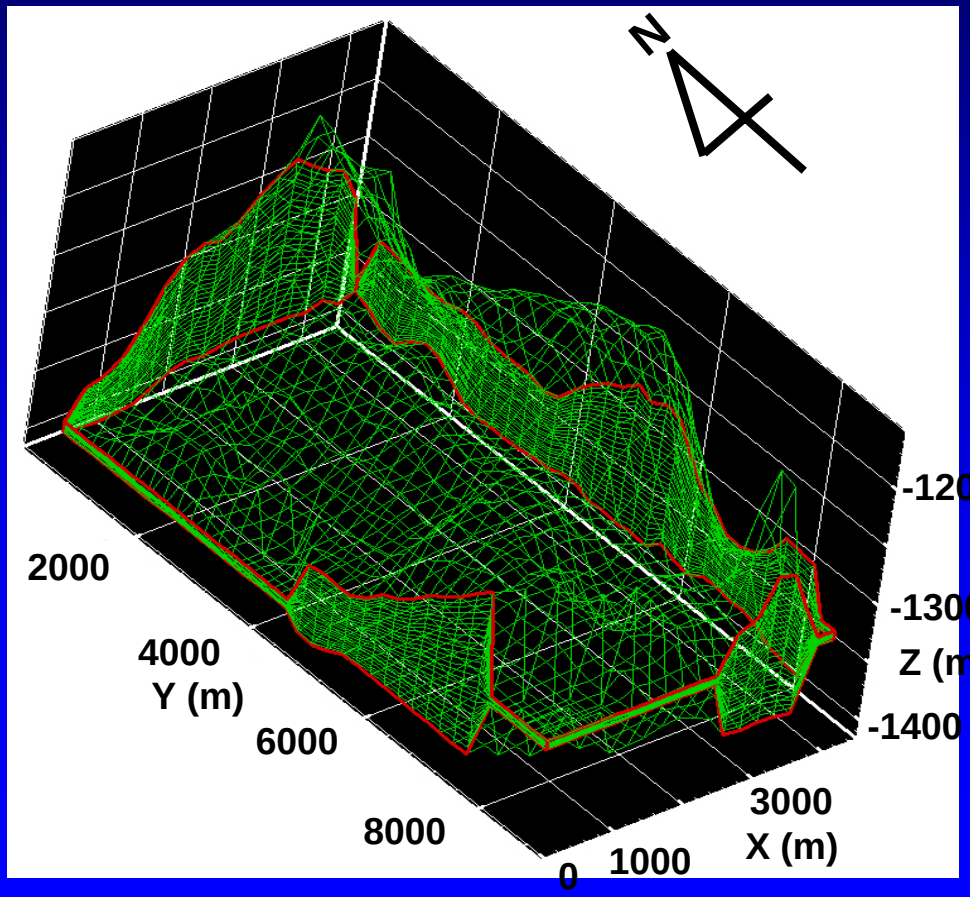
Top boundary "No flow" (Wolfcamp shale seal)

Bottom boundary "No flow" (Canyon shale seal)

Eastern and western boundaries are constant head boundary

Pressure and temperature are reasonably estimated with hydrostatic and 0.025 m/K gradient assumption

Salinity of brine is 159000 mg/L (=2.72 mol/L)

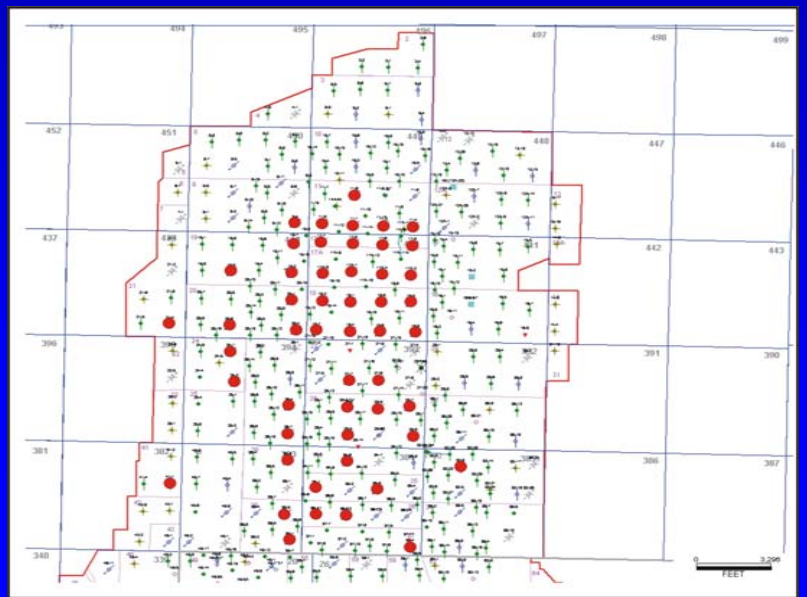


CO_2 Source identification (Injection)

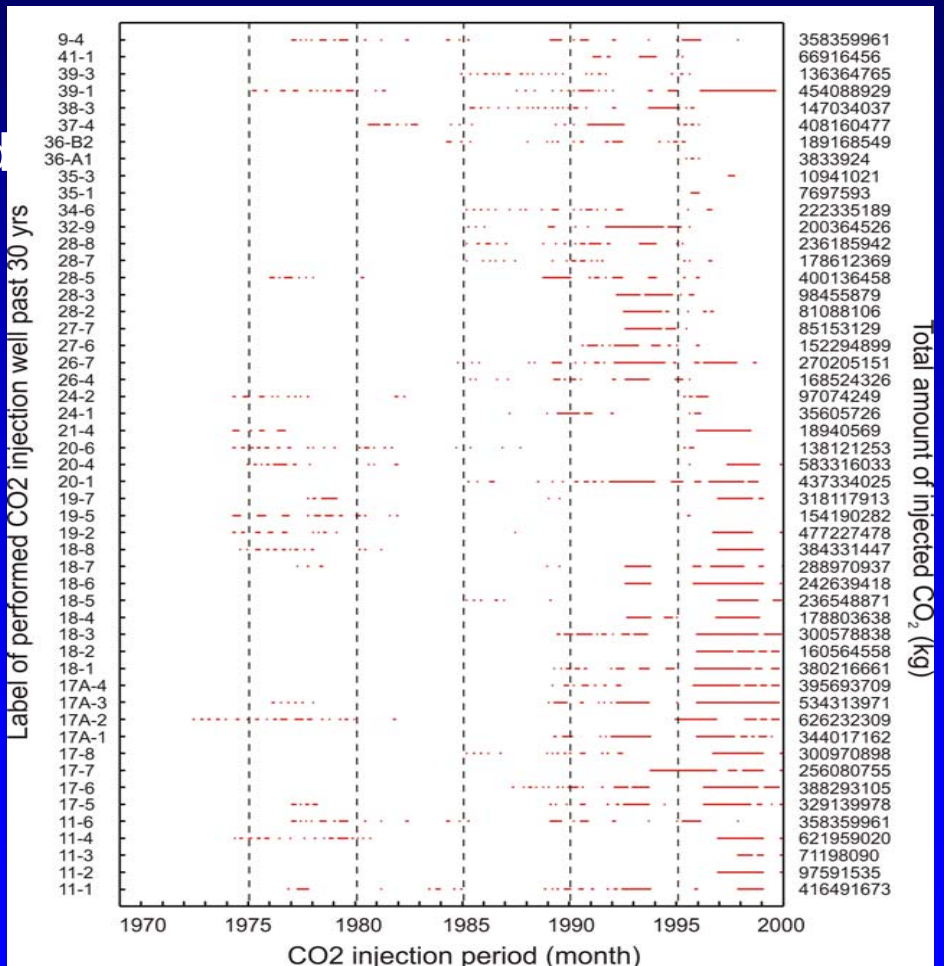
- Among them, 51 well has been active from 1990 to 2000 years

- 13 million tons of CO_2 has been injected at 51 wells during past 30 years

Injection well location



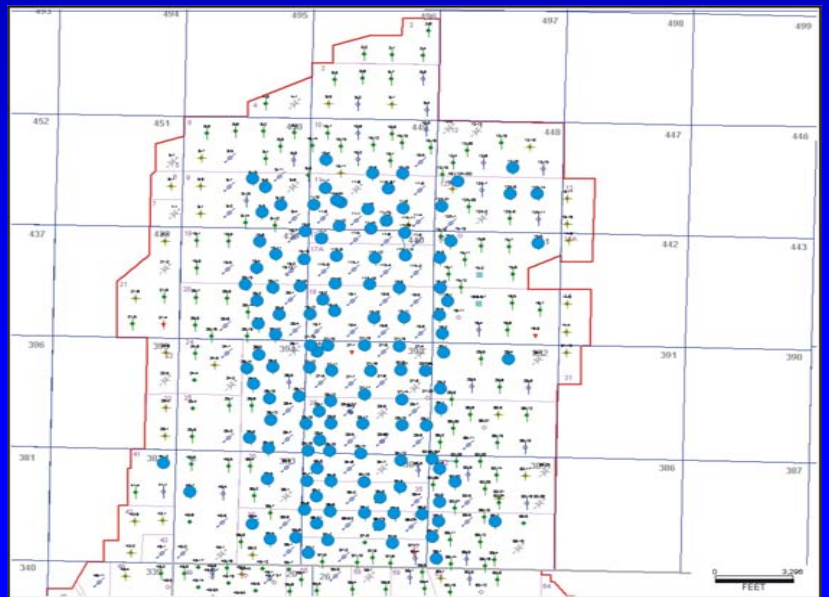
Injection well schedule



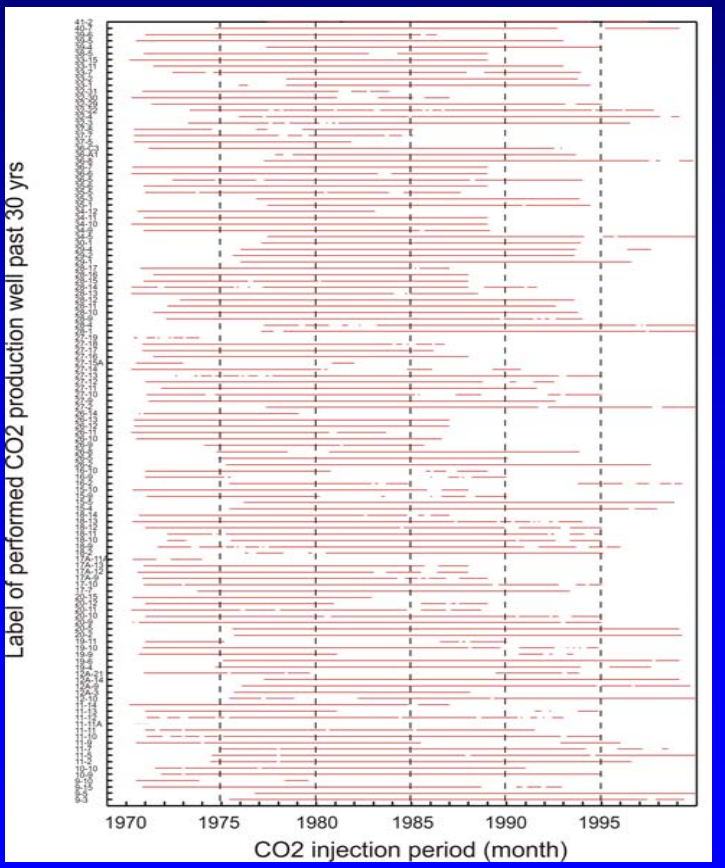
CO_2 Source identification (Production)

- Among them, 124 well has been active from 1990 to 2000 years
- 6,104,258,074 kg (6 million tons) of CO_2 has been produced at 119 wells during past 30 years

Production well location

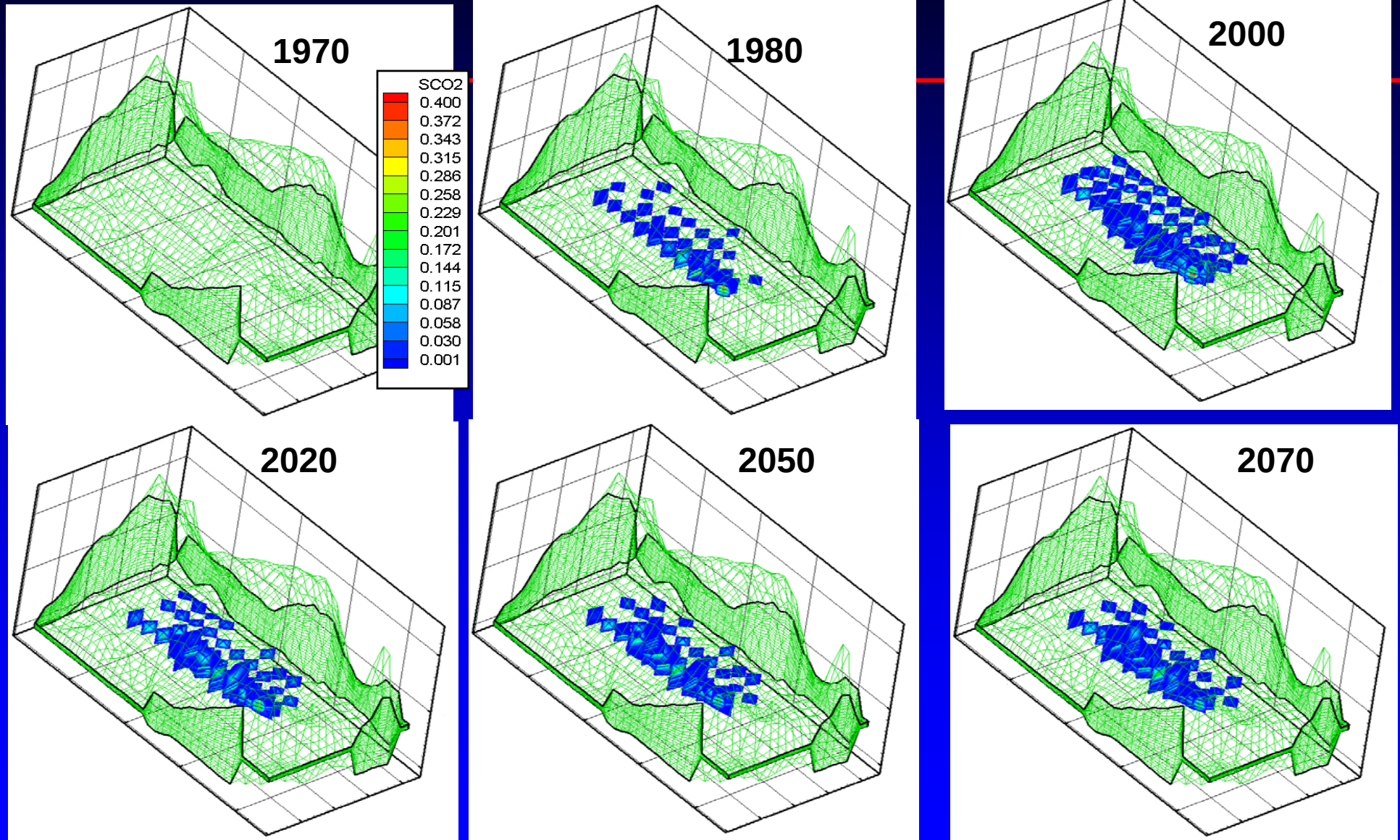


Production well schedule



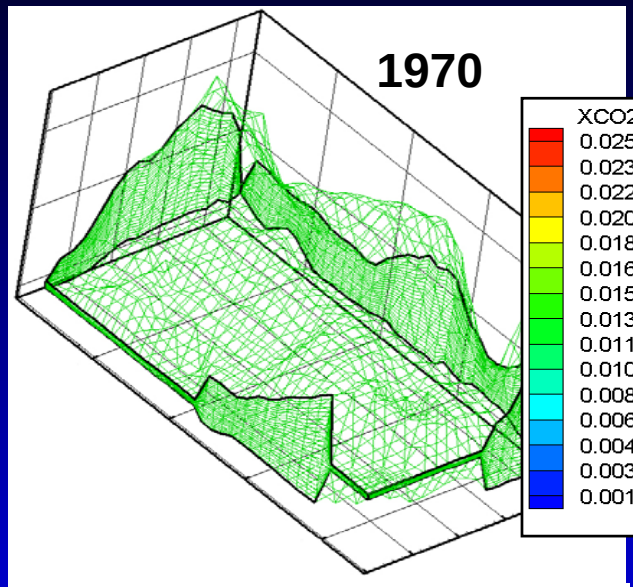
Estimation of spatial distribution of CO_2

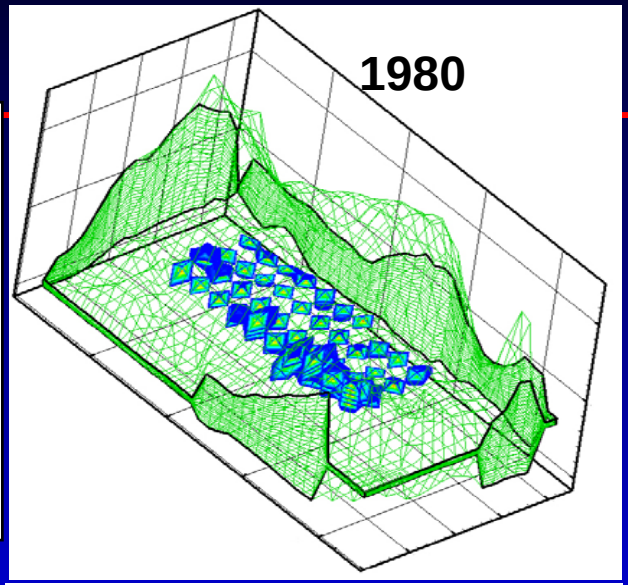
Separate CO_2 distribution

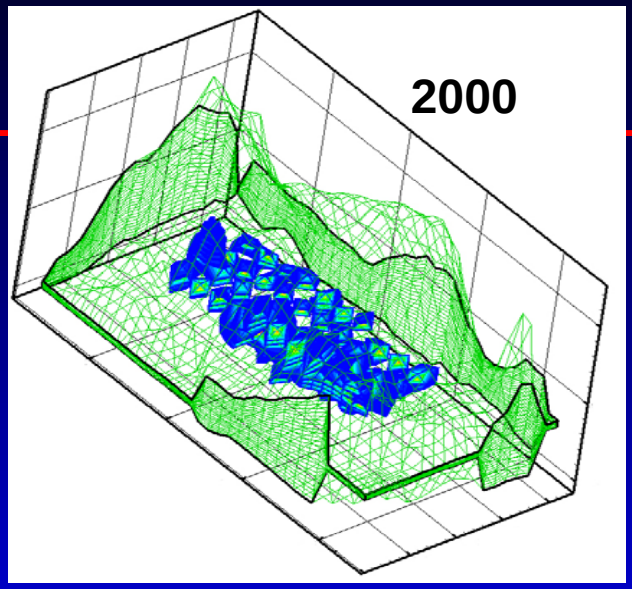


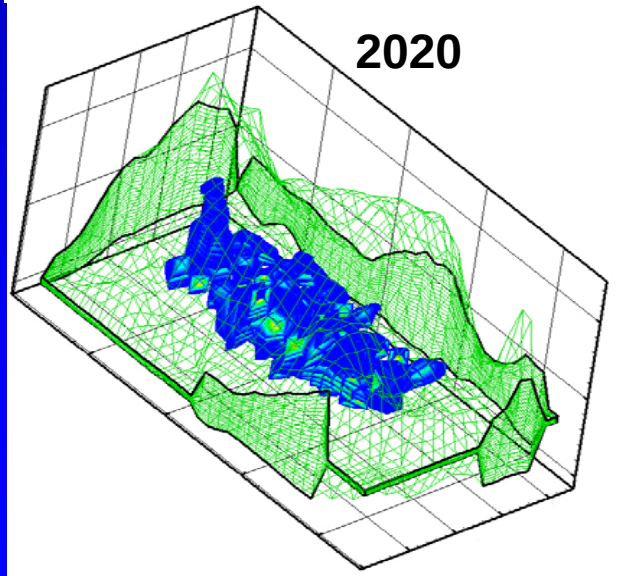
Estimation of spatial distribution of CO_2

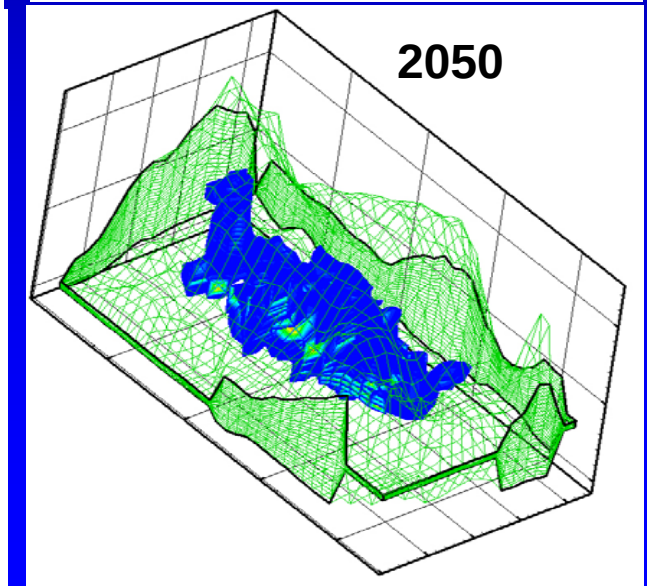
Dissolved CO_2 distribution

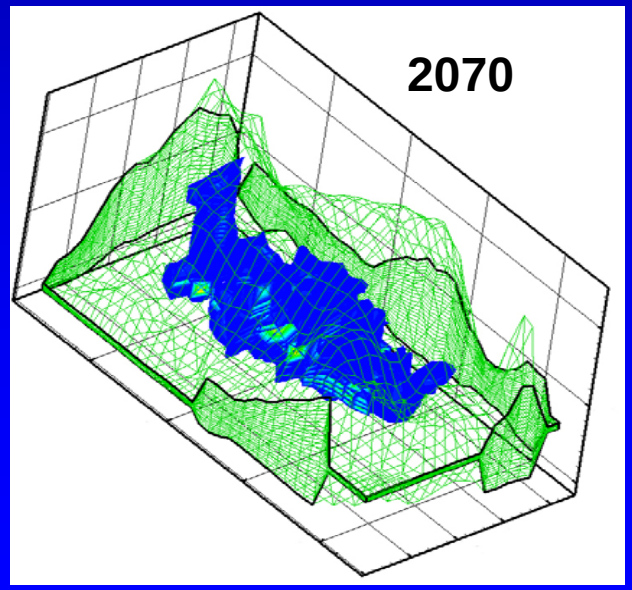













Thank you